THE

WATER WHEEL

May/June 2018 Volume 17 No 3

WHAT DOES DROUGHT DO

to our wastewater treatment plants?

SCHOOL SANITATION

Returning dignity to South African schools

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WATER RESEARCH COMMISSION

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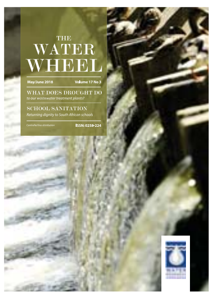

A recently completed project funded by the Water Research Commission has determined the impact of drought on Cape Town's sewage treatment plants. *Read the story on page 12.*

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Editorial offices:
Water Research Commission, Private Bag X03, Gezina, 0031, Republic of South Africa.
Tel (012) 761 9300. **Fax** (012) 331-2565.
WRC Internet address:
http://www.wrc.org.za
Follow us on Twitter:
@WaterWheelmag
Editor: Lani van Vuuren,
E-mail: laniv@wrc.org.za;
Editorial Secretary: Dikeledi Molutsi,
E-mail: dikeledidk@wrc.org.za;
Layout: Anja van der Merwe,
E-mail: anjavdm@wrc.org.za
Printing: Oshiang Printers
Email: info@oshiangprinters.co.za

FLUID THOUGHTS

WRC CEO, Dhesigen Naidoo

Tackling the national innovation challenge to attract investment

The 26 April was World Intellectual Property Day. It's a day of some controversy around the world, and, depending on whether you are a beneficiary or victim of the current global patterns of production and consumption, the day becomes one of hope or one of continued despair. This is based on an age-old discourse that has at its centre the notion of intellectual property rights as both a trade barrier as well as a barrier to localisation and development.

This is an argument worth revisiting frequently as we observe significant changes in the global economic power balances. The rise of China and India in particular has created a slipstream for many developing countries who have responded quite positively. There is a close correlation between the creation of new intellectual property and innovation. An examination of the 2017 Global Innovation Index (GII 2017), compiled by the World Intellectual Property Organisation (WIPO) and its partners, indicates an increasing presence of African countries. South Africa tops the African list coming in at 57th, followed by Mauritius at 64th and Kenya at 80th. But the top end of the list is dominated by high-income, developed countries with 24 of the top 25 in this category. The exception is middle-income China which came in at 22nd. Can South Africa follow in China's footsteps into the top 25?

A closer examination of African development using innovation as a metric makes for interesting study. Many punters agree that developments in ICT and the 4th Industrial Revolution will shape the competitiveness indices going into the future. The World Telecommunication Union's ICT Development Index (WTU IDI) paints an interesting picture with Mauritius topping the African list followed by the Seychelles. South Africa follows only in third place and only one place ahead of Cape Verde with our neighbour Botswana being in 5th position on the continent.

This begins to answer an important question. Why did South Africa come out at 61st out of 137 countries measured in the 2017-18 Global Competitiveness Report from the World Economic Forum? A drop of 14 places from 47th in the previous round. It is an economy that appears to rely on old strengths with mainstays in primary resources and agricultural production. The fast-upward movers are investing in innovation and the infrastructure to enable a knowledge-based economy. So, while South Africa's general infrastructure ranks 46th in the GII 2017, its ICT infrastructure only ranks 78th.

Even more worrying is that fact that while South Africa ranks highly in market sophistication at 21st on the list, its business sophistication at 57th fails to take advantage of this, which goes some way to explain why South Africa is a high import economy. This is exacerbated by the fact that South Africa's knowledge and technology output ranking is a low 65th. An examination of the pipeline shows the following, in spite of a very high investment in education – ranked 20th on the basis of percentage GDP spend on education, the education performance places the country at 75th in the rankings with tertiary education even lower with South Africa in 89th place. Thus, in spite of the fact the South Africa's research and development ranks at 39th, the resultant ranking in the knowledge worker category for the country is only 67th. The knowledge worker capacity and capability remain the absolute key to innovation and global competitiveness.

Another part of the broken telephone reads as follows: South Africa's research and development ranking is a credible 39th – not too far off the leading pack, but this achievement is not optimally realising knowledge creation (ranked only 52nd), which translates quite poorly in the domain of knowledge diffusion (ranked 63rd) that then finds an even more difficult journey into knowledge impact, the latter ranked at 84th in the world. This means that while the country, through both the public and private sectors, is managing to keep the research and development investment and performance at a reasonable level, an uncoordinated National System of Innovation is failing to translate this investment through the creation of new knowledge and intellectual property into the knowledge-based impact that is required for higher levels of economic growth and social well-being.

The remedies have been worked through. The National Advisory Council on Innovation (NACI) has submitted to the Minister of Science and Technology a candid review on the performance of the NSI and recommendations for major changes. The minister,

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in turn, is steering a process to development a new White Paper on Science, Technology and Innovation to create a functional and productive innovation ecosystem in the country. Individual institutions like the Water Research Commission (WRC) are busy putting more effort into building bridges with sister institutions like the Technology Innovation Agency (TIA) and other public and private partners to translate the research and development investment into real dividend. It does require higher levels of innovation investment and broader partnerships like the promising Creative Leadership Collective Africa (CLC Africa) – an expanding team of innovation leaders in public institutions and private companies developing a new innovation narrative for the country.

The bottom line is that an innovative and higher technologically capable South Africa, boasting a strong knowledge worker base, will be a magnet for the $100 billion that is the first target for foreign direct investment in President Cyril Ramaphosa's plan. But it has to be leveraged with an internal investment to create the conditions necessary for the courting to be successful and productive.

WATER DIARY

Aquatic science
June 24-28
The Southern African Society of Aquatic Scientists will be holding its 2018 congress in Cape St Francis Bay resort, in the Eastern Cape. The theme for the congress is 'Aquatic ecology in the Anthropocene'. Enquiries: Petrie Vogel (conference organiser); Tel: (12) 346-0687; Email: admin@savetcon.co.za;
Visit: www.savetcon.co.za

Water resource management
June 24-27
The Water Institute of Southern Africa (WISA) is hosting its biennial conference at the Cape Town International Convention Centre. **Visit: www.wisa2018.org.za**

Large dams
July 1-7
The 26th Congress of the International Committee on Large Dams (ICOLD) will take place in Vienna, Austria.
Visit: www.icoldaustria2018.com

World water week
August 26-31
World Water Week is the annual focal point for the globe's water issues. It is organised by the Stockholm International Water Institute. The theme is 'Water, ecosystems and human development'.
Visit: http://www.worldwaterweek.org/

Wetlands
October 8-11
The National Wetlands Indaba will take place at the Mittah Seperepere Convention Centre, in Kimberley, Northern Cape. The theme of the conference is 'Drylands and wetlands: connecting and managing heterogeneity across landscapes'.
Visit: www.nationalwetlandsindaba2018.com

Municipal engineering
October 31-November 2
The annual conference of the Institute of Municipal Engineering of Southern Africa will be held in Port Elizabeth with the theme, 'Innovative infrastructure solutions'.
Visit: www.imesa.org.za.

Irrigation engineering
November 13-15
The South African National Committee on Irrigation and Drainage (SANCID) will be holding its 2018 conference with the theme 'Opportunities to management climate change'. The conference will be held in White River, Mpumalanga.
Visit: www.sancid.org.za

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NEWS

Web app help users to save water

Global firm of engineers and scientists SRK Consulting has long been in the business of helping clients manage their water sustainably; now it has brought water saving closer to home with an innovative web app that can get individuals to reduce their domestic water use – introducing fun and competition to the exercise.

The brainchild of two young colleagues – environmental and civil engineer Xanthe Adams in Cape Town and civil engineer Whelan Naidoo in Johannesburg – WaterWar is an app that goes beyond just calculating water use; it uses peer pressure as a motivator for saving water. The app allows people and companies to compete with each other, while keeping the interface simple and easy to use.

"The idea was to get people interested and engaged by playing a game – so our concept is really a combination of water sciences, programming and psychology," said Adams. "To work as a game, the output needed to be comparable between users; we settled on the calculation of litres used per person per day, based on the household water bill."

The developers also realised that the data input needed to be quick and easy, and therefore based the calculation on how many people live in the household. If users want to get into more detail a few other simple variables – such as the duration of showers, half-flush toilets and dishwasher cycles – can be input.

"Input take the user less than five minutes, and can all be seen on one page with an immediate result," noted Adams.

Competition between the SRK branches using the app saw an 8% decrease in water use over six months. The Cape Town group has saved over 1 730 kilolitres since they started using the app in 2016.

For more information about the app, Visit: www.waterwars.co.za/

Work underway to replace school pit latrine backlog

The Department of Basic Education (DBE) says judgement in the Michael Komape case, ordering the department to replace all pit toilets in Limpopo, comes as work is already underway to fast track sanitation infrastructure.

Michael Komape lost his life at the age of five when he fell into a pit latrine at his primary school. On 23 April, Judge Gerrit Muller handed down judgement in the Limpopo High Court in Polokwane.

"This judgement comes at a time when, as the Department of Basic Education, we are seized with the matter of school infrastructure and pit latrines, particular as per President Cyril Ramaphosa's directive that addressing sanitation infrastructure backlogs must be accelerated.

"As a result, an audit of all school toilets is currently underway in all provinces and a comprehensive costed plan will be given to the President for consideration within the set timelines," said the department in a statement.

Following the death of five-year-old Lumka Mkhethwa of Luna Primary School in Bizana, Eastern Cape, who met the same fate as Michael last year, President Ramaphosa issued a directive to the department to urgently address the sanitation infrastructure backlog.

Judge Muller dismissed the R3 million financial compensation claims of the family but ordered the Limpopo Education Department and the DBE to replace all pit toilets in rural Limpopo schools. The order will be under the supervision of the court. The judge said getting the department to replace all pit latrines in the province is more beneficial to all learners than the awarding of compensation on constitutional grounds to one family.

Source: www.sanews.gov.za

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African biodiversity and ecosystem services in decline – report

The world's first comprehensive, evidence-based regional assessment of biodiversity and ecosystem services for Africa compiled by over 100 experts across 45 countries has been completed.

The governments of 129 member nations approved the report at the sixth session of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in Colombia earlier this year. The objective of the IPBES, established in 2012, is to strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human wellbeing and sustainable development.

"Africa's immense natural resources and its diverse cultural heritage are among its most important strategic assets for both human development and well-being." This is according to CSIR chief scientist, Dr Emma Archer, who co-chairs the African Assessment along with Dr Luthando Dziba of South African National Parks and Prof Kalemani Joseph Mulongoy of the Democratic Republic of Congo.

"Today there are more African plants, fish, amphibians, reptiles, birds, and large mammals threatened than ever before by a range of both human-induced and natural causes," noted Dr Archer.

The African Assessment report is one of four regional assessments of biodiversity and ecosystem services. The other three assessments cover the Americas, Asia and the Pacific as well as Europe and Central Asia. The assessment reports point to a decline in biodiversity in every region of the world, thus significantly reducing nature's capacity to contribute to human well-being.

Biodiversity and nature's capacity to contribute to people are being degraded, decreased and lost due to a number of common pressure, including climate change, overexploitation and the unsustainable use of natural resources and habitat stress, among others. However, measures taken by African governments to protect biodiversity and nature's contributions to people have contributed to some recovery of threatened species. Such measures include the establishment and effective management of protected areas and networks of wildlife corridors, as well as the reintroduction of wildlife, among others.

South African firm completes water projects for Tanzanian mine

Veolia Water Technologies South Africa has completed a three-part project for Shanta Gold in Tanzania at its New Luika Gold Mine.

The firm's scope of work incorporated fabrication, installation and commissioning of a river water treatment package plant and skid-mounted borehole water treatment plant, as well as supplying equipment for, refurbishing and commissioning an existing sewage treatment plant.

The plants were commissioned in April. Equipment fabrication was collected from the firm's premises in Johannesburg to the mine, located in south-west Tanzania.

The 30 m^3/h river water treatment package plant treats water from the nearby Luika River for use as process water. The plant uses clarification with appropriate chemical dosing to ensure the clarifier operates efficiently, as well as multimedia filtration, activated carbon filtration and pre- and post-chlorination.

In turn, the 5 m^3/h skid-mounted borehole water treatment plant is used as post-treatment for an existing water treatment plant. Veolia's engineered skid uses a chlorine dosing unit, carbon filter and softener to treat the water for the mine camp's potable water needs. Veolia also refurbished the existing sewage treatment works.

"As most of the plants are automated, operator training was minimal and took place simultaneously to commissioning," said Sean Momberg, Project Engineer, Engineered Systems, Veolia Water Technologies South Africa. "All equipment was manufactured on time and to spec, and even with the short lead time we completed the manufacture of the plants within the specific time limits. It took a bit longer on site to install the plants than initially expected due to the rugged and isolated area that the New Luika Gold mine is situated in, but the Shanta Gold and Veolia site teams worked together admirably to get the plants up and running in the shortest possible time."

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GLOBAL

US & Dutch professors share international water prize

Professors Bruce Ritmann and Mark van Loosdrecht have been named the 2018 Stockholm Water Prize Laureates for revolutionising water and wastewater treatment.

By revolutionising microbiological-based technologies in water and wastewater treatment, the professors have demonstrated the possibilities to remove harmful contaminants from water, cut wastewater treatment costs, reduce energy consumption, and even recover chemicals and nutrients for recycling.

Their pioneering research and innovations have led to a new generation of energy-efficient water treatment processes that can effectively extract nutrients and other chemicals – both valuable and harmful – from wastewater.

Mark van Loosdrecht is Professor in Environmental Biotechnology at Delft University of Technology, in the Netherlands. Bruce Rittmann is Regents' Professor of Environmental Engineering and Director of the Biodesign Swette Centre for Environmental Biotechnology at the Biodesign Institute, Arizona State University, in the US.

In its citation, the Stockholm Water Prize Nominating Committee recognised Profs Ritmann and van Loosdrecht for "pioneering and leading the development of environmental biotechnology-based processes for water and wastewater treatment. They have revolutionised treatment of water for safe drinking, and refined purification of polluted water for release or reuse – all while minimising the energy footprint."

The professors' research has led to new processes for wastewater treatment currently being used around the globe. "Traditionally, we have just thought of pollutants as something to get rid of, now we're beginning to see them as potential resources that are just in the wrong place," noted Prof Rittmann. "We're in the middle of a paradigm shift, with more and more focus on how we can create resources, using microbial systems."

Historic agreement signed to protect the world's largest tropical peatland

In an unprecedented move to protect the Cuvette Centrale region in the Congo basin, the world's largest tropical peatlands, from unregulated land use and prevent its drainage and degradation, the Democratic of Congo, the Republic of Congo and Indonesia jointly signed the Brazzaville declaration that promotes better management and conservation of this globally important carbon store.

There is a lot at stake in the protection of these peatlands: the equivalent of three years of global greenhouse gas emissions are stored in the Congo basin, emissions that could be released if the peatlands are degraded or the natural wetlands drained.

To preserve the future of these valuable natural peatlands – which are about the size of England, and were only mapped scientifically in their entirety for the first time last year – the DRC and the Republic of Congo established a transboundary collaboration agreement. The agreement noted the importance of good land use and infrastructure planning that takes the nature of peatlands into account.

"Conservation and development can go hand in hand," said Erik Solheim, Head of UN Environment. "We will manage to conserve the peatlands if we put people's needs first. We can help countries to better understand the unique nature of the peatlands, and plan very carefully for any potential use.

Peatlands are wetlands that contain a mixture of decomposed organic material, partially submerged in a layer of water, lacking oxygen. The complex biodiversity of the peatlands means they are home to a variety of species, but their high carbon content makes them uniquely vulnerable to incineration if they are drained. The declaration recognises the importance of the scientific breakthrough of mapping the world's largest tropical peatland area.

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UN launches new global decade for action on water

The United Nations has launched a ten-year water action plan that seeks to forge new partnerships, improve cooperation and strengthen capacity to implement the 2030 Agenda for Sustainable Development.

Most directly linked to Sustainable Development Goal (SDG) 6, safe water and adequate sanitation are indispensable for healthy ecosystems, reducing poverty, and achieving inclusive growth, social well-being and sustainable livelihoods – the targets for many of the 17 Goals. However, growing demands, poor management and climate change have increased water stresses and scarcity of water is a major problem in many parts of the world.

Furthermore, more than two billion people worldwide lack access to safe water and over 4.5 billion to adequate sanitation services, warned UN Secretary General António Guterres. "By 2050 at least one in four people will live in a country where the lack of freshwater will be chronic or recurrent."

Stressing that water cannot be taken for granted, the UN chief said that while solutions and technologies to improve water management exist, these are often not accessible to all. "As with most developmental challenges, women and girls suffer disproportionately. For example, women and girls in low-income countries spend some 40 billion hours a year collecting water," he noted.

The ten-year action plan hopes to place greater focus on the sustainable development and integrated management of water resources for achievement of social, economic and environmental objectives; the implementation and promotion of related programmes and projects; and the furtherance of cooperation and partnerships at all levels to achieve internationally agreed water-related goals and targets, including those in the 2030 Agenda for Sustainable Development.

To learn more about the action plan, visit: www.wateractiondecade.org

Device harvests water from desert air

Even in the most arid places on Earth, there is some moisture in the air, and a practical way to extract that moisture could be a key to survival in such bone-dry locations. Now, researchers at MIT in the US have proved that such an extraction system can work.

The new device, based on a concept the team first proposed in 2017, has now been field-tested in the dry air of Tempe, Arizona, confirming the potential of the new method, though much work remains to scale up the process, the researchers say. The new work is reported in the journal ***Nature Communications***.

The system, based on relatively new high-surface-area materials called metal-organic frameworks (MOFs) can extract potable water from even the driest of desert air, the researchers say, with relative humidities as low as 10%. Current methods for extracting water from air require much higher levels – 100% humidity for fog-harvesting methods, and above 50% for dew-harvesting refrigeration-based systems, which also require large amounts of energy for cooling.

The test device was powered by sunlight, and although it was a small proof-of-concept device, if scaled up its output would be equivalent to more than a quarter litre of water per day per kilogram of MOF, the researchers say. With an optimal material choice, output can be as high as three times that of the current version, according to project team leader Evelyn Wang.

The next step, Wang says, is to work on scaling up the system and boosting its efficiency.

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THE WATER WHEEL

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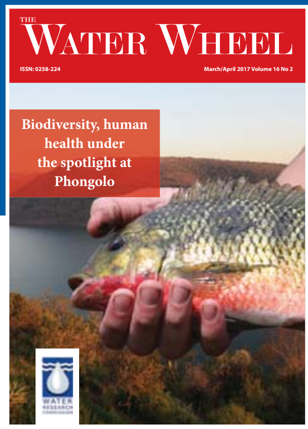

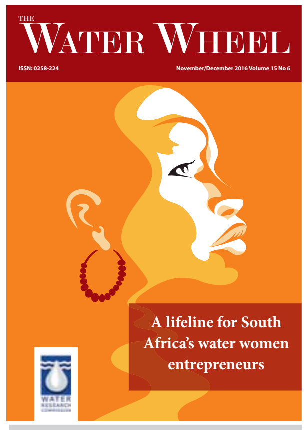

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WATER RESEARCH COMMISSION

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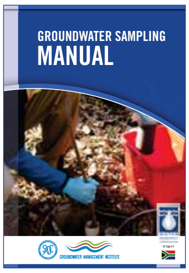
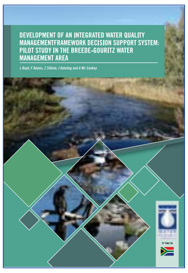
Tel: +27 (0) 12 761-9300
Fax: +27 (0) 12 331-2565
E-mail: laniv@wrc.org.za /www.wrc.org.za
Physical address: Lynnwood Bridge Office Park, Bloukrans Building, 4 Daventry Street, Lynnwood Manor
Postal address: Private Bag X03, Gezina, 0031

NEW WRC REPORTS



Groundwater sampling manual
As drought grips large parts of South Africa, the importance of groundwater as a secure source of water for domestic and agricultural needs has become clear. However, while many people think of groundwater as an unlimited resource, groundwater does have a finite limit and needs to be managed sustainably to ensure future supply. Groundwater sampling is essential to determine and maintain the distribution of renewable groundwater resources in South Africa. There is no best single method that will suit all groundwater sampling objectives or is applicable at all sites or times. Thus, as new methods, techniques and equipment are developed, there is a need to continuously update groundwater sampling manuals. Now in its third edition, the latest groundwater sampling manual aims to provide consistent groundwater sampling techniques.
Report no. TT 733/17



Development of an integrated water quality management framework decision support system: Pilot study in the Breede-Gouritz water management area
The aim of this project was to pilot the integrated water quality management system (IWQMS) that was developed a previous WRC project by introducing the proposed decision support system to an existing institution, to undertake a literature review on early warning systems and propose how the various options could be incorporated into the IWQMS. The benefits of such a system are: close to real-time water quality/ quantity reporting by the water users; close to real-time access to water quality/ quantity monitoring information; simplified reporting for the regulators; potential to include civil society organisation in the input of water quality data; and the potential for spreading the monitoring footprint and reducing the cost of monitoring to the regulator.
Report no. TT 740/17

Approaches for emerging farmer participation in water resource management: The case of the Breede-Gouritz Catchment Management Agency (BGCMA), Western Cape
After many years of water allocation reform, emerging farmers are still lagging behind as far as equity and access to water resources is concerned, and their participation in water user associations is still limited or passive. The catchment management agencies (CMAs), that have the mandate to provide access to water to these farmers, are faced with various challenges, including water scarcity, drought, climate variability, and challenging institutional arrangements. The extent of these problems varies from CMA to CMA. This project was conceived as a result of discussions with the BGCMA. The research project focused on emerging farmers. The main aim was to assess some of the issues and challenges that have resulted in limited progress in water allocation to historically disadvantaged individuals in the BGCMA, despite all the efforts put into the processes; and to explore ways to alleviate the situation.
Report no. 2310/1/17

Multi-array sensor technology for polycyclic aromatic hydrocarbons screening in wastewater
Polyaromatic hydrocarbons (PAHs), also called polycyclic aromatic hydrocarbons, have been included in the overarching definition of persistent organic pollutants (POPs). POPs are, typically, organic compounds that are not easy to degrade using conventional methods and which pose a serious threat to the balance of natural ecosystems. The need for low-level detection and quantification of these compounds still presents serious challenges currently, notwithstanding the advances in technology materials and methods that have been made, over the years. The main objectives of the project were the demonstration of a one-pot electro-analytical protocol for on-site, real-time analysis of PAH hydrocarbons in a mixed sample.
Report no. 2454/1/17

An evidence-based approach to measuring the costs and benefits of changes in aquatic ecosystem services
Human well-being and ecosystems are intimately connected. Human understanding of the value of ecosystems has matured rapidly over the past two decades. The Millennium Ecosystem Assessment's (MEA) concept of ecosystem services introduced a radical new framework for analysing the value of ecosystems, and this, combined with electronic data collection systems and rapidly increasing computing power has enabled us to improve both our understanding of the value of ecosystems as well as the accuracy of valuations. Yet, despite our improved understanding and our improved valuation techniques, evidence of severe ecological degradation is evident all around us. In this study, the project team focused on aquatic ecosystem services produced by urban river systems. These ecosystem services are especially relevant in South Africa where rapidly increasing urbanisation puts significant pressure on scarce water resources.
Report no. TT 726/17

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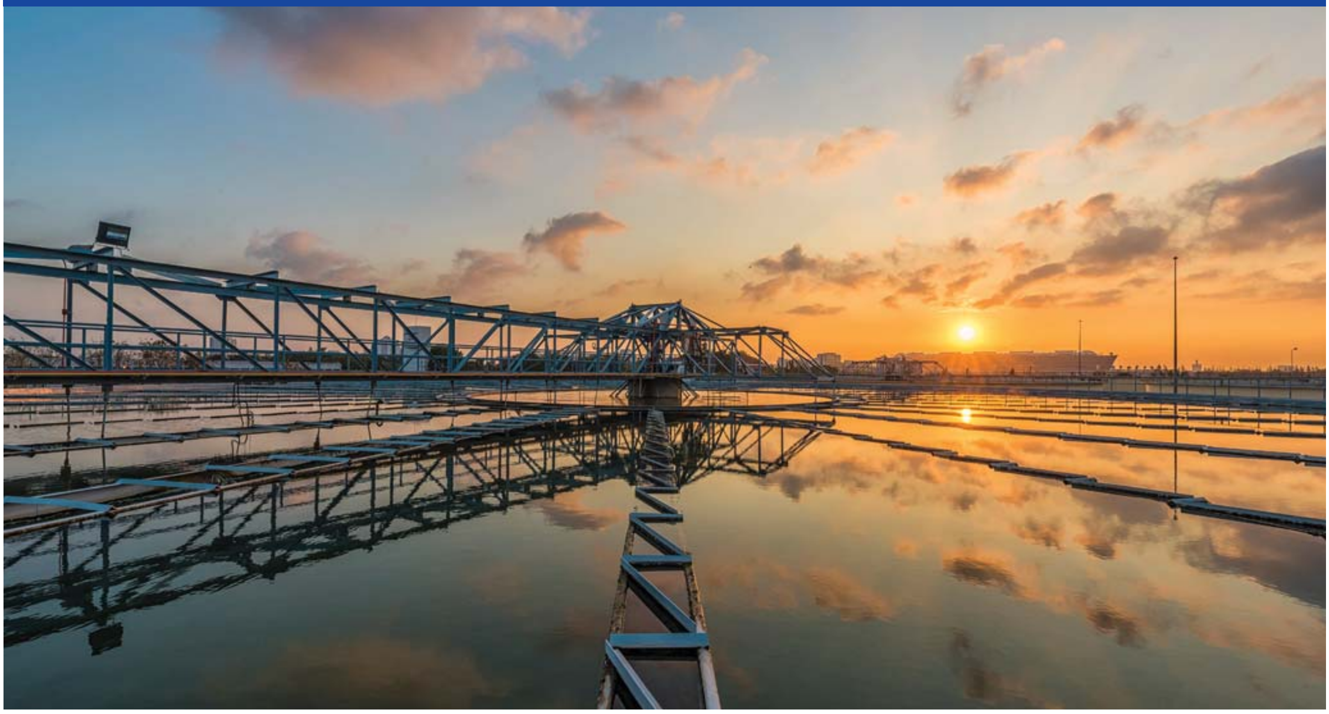
WASTEWATER

Cape Town drought places sewerage systems under pressure

What is the impact of severe drought on local sewerage systems and wastewater treatment plants? Jorisna Bonthuys reports on new research funded by the Water Research Commission (WRC) on this topic.



The ongoing drought in the Western Cape – the worst in recent decades – is not only having a significant impact on agriculture and other local industries but also impacts on wastewater treatment plants in the Cape Metropole region.

This is evident from new research funded by the WRC. The study by Gina Pocock and Hannes Joubert from VitaOne8 (Pty) Ltd considered the extent of negative impacts of the ongoing drought and subsequent water demand management on wastewater influent flows and quality. This Pretoria-based consultancy company does research and development of water treatment technologies, among others.

The researchers wanted to understand how drought affects local wastewater systems and find ways to minimise these impacts on water quality and quantity. Their study titled *Effects of reduction of wastewater volumes on sewerage systems and wastewater treatment plants* included a review of international case studies, as well as a local case study focusing on the City of Cape Town's sewerage system.

When the idea of the study was perceived, the impact of the drought extended far beyond the regions of the Western Cape. However, by the time that the study commenced, there was a relief after good rainfall in all the regions except the Western Cape. Most of the regions previously affected by the severe drought were rural areas where information with respect to flows and loads are not recorded, and it could not be used for a quantitative study of the impact of the drought. It was therefore decided to focus the study on the Western Cape, Joubert points out.

The City of Cape Town, in particular, has been under tremendous pressure because of the ongoing drought. By the end of

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May last year the drought had been declared the worst in a century. Climatic factors are major causes of the current situation. Other factors that have exacerbated the crisis include population growth, increased water pollution, the state of water infrastructure and its current management. These factors have resulted in the lowest dam levels for the Western Cape ever recorded. The current crisis requires innovative ways of thinking about water resource management in the region, the study highlights. This includes looking at water quality and quantity in sewerage systems.

Very few such studies have been conducted on this topic, with most of the information available emanating from research done in California during the severe drought experienced there in the 1970s. Local conditions differ, highlighting the need for appropriate local guidelines to deal with drought impacts on wastewater treatment works.

The researchers, therefore, reviewed water quality monitoring data from local plants to determine flow and quality changes over the last five years. They also considered how efficient the disinfection systems are under reduced flow conditions and conducted interviews with plant managers and municipal infrastructure managers. They used data from nine wastewater treatment plants in the Cape Metropole area. Reductions in flow due to water restrictions during the study period (July 2016 to June 2017) ranged from 17% to 52%. At a time the region was under level 4b and level 5 water restrictions.

It appears operational challenges experienced by local plants were similar to those experienced internationally. In terms of the raw water quality impacts, the concentration of wastewater parameters, notably the chemical oxygen demand and suspended solids, increased proportionally to the reduction in flow in most cases.

The local case study had some contrary findings to global studies on the topic. There was a reduction of the flow in all the plants studied. In the international case studies, there was also a decrease in plant loading in some cases, which was attributed to solids deposition in the sewers. "While the plant loading in terms of the chemical oxygen demand and suspended solids showed a decrease in most cases, there was no evidence of solids settling or degradation of organic material in the sewers," Pocock points out. This is most likely due to all the sewers being reticulated with pump stations, she says. The decrease in loading was attributed to reduced industrial discharge as a result of the severe water restrictions.

This finding may be specific to the City of Cape Town, according to the research. Other municipalities with gravity fed sewers or reticulated networks with large sumps are likely to experience solids deposition and anaerobic conditions similar to those seen overseas.

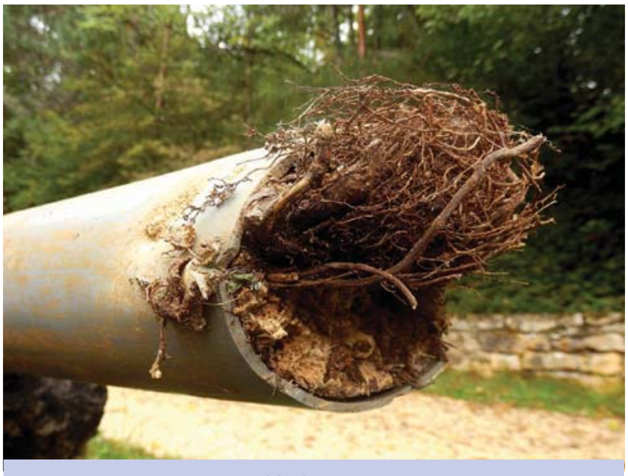
In general, in the international studies, plants performed better under low flow conditions in terms of compliance, mainly as a result of longer retention time in final clarifiers. Local plants struggled with compliance issues concerning suspended solids, chemical oxygen demand and ammonia levels. "In most cases, the local plants were already operating above their hydraulic design capacity before the drought, so the potential benefits of a reduced hydraulic load described in the international review were not necessarily realised," Pocock explains. "Even with flow reductions, three plants of the nine surveyed were still operating above their average hydraulic design capacity, and these plants showed the least impact in terms of effluent compliance. These plants may have also had less operational flexibility than those reviewed in the international studies."

The findings of the literature review revealed that conditions such as climate, integration of stormwater with sewerage and the disposal of garbage, such as kitchen waste to the sewers in the global case studies, differed from the South African conditions. Pocock highlights, "The local findings did not correlate well with those of the international studies, mostly due to lower per capita usage under normal conditions, and plants likely not having the same degree of flexibility."

In both the international and local case studies, smaller plants and plants using biofilter technology were the most affected, with larger plants with activated sludge technology being more flexible and more able to handle the increased organic load.

Plants with inherent flexibility, such as the ability to take settling tanks and biological nutrient removal systems offline during low flow conditions, and allow for the recycling of effluent within the plant to maintain hydraulic load were able to withstand low flow conditions better than inflexible systems. "Training of plant managers and operators on mitigation measures can also assist in preventing operational problems and issues of non-compliance," Pocock emphasise.

"In most cases, the local plants were already operating above their hydraulic design capacity before the drought, so the potential benefits of a reduced hydraulic load described in the international review were not necessarily realised."



Tree roots blocking a sewer pipe.

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When blocked sewers were cleared with storm water the plants received a large amount of grit.

From an environmental and health perspective, the treated wastewater becomes a larger fraction of surface water flow when drought conditions caused lower minimum flows in rivers. This results in higher concentrations of selected wastewater contaminants, including conductivity, phosphates, nitrates, and pharmaceuticals and endocrine disrupting compounds. This may place more pressure on wastewater treatment works to comply with even more stringent discharge standards, and may in turn force stricter by-laws in the industrial water users. Pocock elaborates, "In many of the rural areas, and in particular during a severe drought, communities are dependent on natural streams to wash themselves as well their clothes and eating utensils. When the discharge from wastewater treatment plants is the only water available in the region, the risk of infections and spread of diseases may be unacceptably high. It is important for municipalities to consult with local industries and communities to communicate these risks."

The impact of reduced wastewater, especially as a result of unexpected drought conditions rather than planned demand management measures, can also be significant. Pocock explains, "Municipalities and local government are becoming more aware of the need to manage water resources carefully, with many planning the implementation of demand management strategies. The impact of reducing the wastewater volumes through water saving should not be discounted, as the costs to infrastructure and the environment may outweigh savings if necessary measures are not taken into account.

"Any new conveyance (piping, pump stations) infrastructure and wastewater treatment facilities should be designed to be flexible to allow for wider ranges in wastewater flow to prevent blockages, odour and degradation of the wastewater in the conveyance systems and operational and compliance issues at the plant. Where possible, flow reduction should be planned and phased in, whether as a result of drought conditions or demand management, to allow for the appropriate response of the operations and maintenance staff responsible for the conveyance and treatment plant infrastructure."

Pocock says it was "surprising" that so few such studies have been conducted in recent years on this topic, given the impacts of climate change and reduced rainfall in many regions. Very few issues were also reported concerning odour and blockages in the local case study. This was likely due to the sewer lines mostly being reticulated with pump stations.

"While wastewater flow reduction due to drought conditions or demand management in South Africa resulted in many of the impacts described in the international case studies, the different conditions in our case study highlighted the need for

Ponding on biofilter due to blockages.

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Sludge bulking in an activated sludge reactor

the development of a guideline document that also draws from local observations and experiences," Pocock says. This was then developed as part of the study.

Although the target audience of this document is municipalities with established wastewater conveyance and treatment infrastructure, the study recommends that undeveloped and rural municipalities should also use it. Where the implications of low flow conditions on these systems can be mitigated efficiently, this may according to the researchers lead to improved Green Drop Assessments for municipalities that may otherwise fail.

The guideline could be used to develop training material for municipalities and plant operators and in awareness campaigns for engineers involved in designing new plants. "As water conserving communities move toward a reduction in system-wide wastewater flow generation, the planning, design, construction, operation, and financial management of a wastewater treatment plant must change to meet the needs of future wastewater collection and treatment facilities that serve them," Pocock says.

Smaller collection systems and flow based wastewater treatment processes may be considered in future when planning infrastructure for water conserving communities. The biological and biosolids treatment and disposal systems for these communities will, however, continue to be similar in size and capacity to the systems needed by those communities that are not conserving water.

In future, local wastewater treatment facilities may also feed more water reuse plants that need predetermined effluent quality. This may impact the design of any proposed reclamation plants, the study highlights. Water reuse is likely to become more prevalent in many municipalities going forward, with some already having implemented this, or at feasibility stage.

And while water-savings or restriction programs are expected to result in some reduction in wastewater flows, they are not expected to reduce the mass of pollutants discharged. The effect of a water conservation programme initiated during the life of the plant will be to reduce expected flows while still retaining the expected pollutant load. In the case of new facilities, the existence of or intention for a water conservation program should be considered in the design process.

The researchers believe more work is needed to expand the database of knowledge of the impacts of more plants of different sizes and to understand the effects of low flow conditions on gravity fed sewers. Currently, information on such systems is lacking.

"Ideally, the research should be extended to include more plants from other regions with extended periods of imposed water restrictions due to demand management or drought conditions," Pocock concludes.

The final report will be available later this year.

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URBAN WATER SUPPLY

Post Day Zero – Lessons in resilience from São Paulo

With burgeoning populations coupled with extreme weather conditions driven by climate change, cities around the world are grappling with maintaining adequate water supply to their millions of residents. Just like Cape Town, the Brazilian city of São Paulo has come precariously close to running out of water. Petro Kotzé reports.

The term Day Zero has for most South Africans (and many beyond the country's borders) become synonymous with Cape Town. Already restricting residents to a daily limit of 50 litres of water per person since February, Day Zero is when dam levels reach 13.5% and city management will turn the taps off. Residents must then queue for 25 litres each at approximately 200 sites across the peninsula. At the time of writing this article, this date was indefinitely staved off due to the combined result of reduced consumption, management of water releases by the Department of Water and Sanitation, water donation from the farmers in the Palmiet River basin and the implementation of tariff management measures by the City.

The crisis seems unprecedented, but Cape Town is not the only major city that has come precariously close to running out of water. In 2015, São Paulo, one of the 10 largest metropolitan areas in the world, had less than 20 days of water left for its near-22 million population. The city has since emerged more resilient to drought, but in the words of Jerson Kelman, CEO of São Paulo's water and sewage supplier, Companhia de Saneamento Básico do Estado de São Paulo (SABESP), "we should strive for the best but be prepared for the worst."

The sentiment has resonance far beyond Brazil. A projected 6.4 billion people will live in cities by 2050, with a projected

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estimate of 55% increase in water demand. Simultaneously, water will become increasingly scarce and the playing field more uncertain. Urban water managers are set to face unprecedented challenges in future, and the lessons learned from cities like São Paulo can offer valuable knowledge to those that are responsible for keeping the taps running elsewhere.

An unprecedented drought

São Paulo is the industrial centre of Latin America. The city, capital of São Paulo state is in south-eastern Brazil, 350 km southwest of Rio de Janeiro. It is located on a plateau of the Brazilian Highlands, extending inland from the Serra do Mar, which rises as part of the Great Escarpment. Located 820 m above sea level, the city sits in a shallow basin surrounded by valleys and foothills now blanketed with vast industrial suburbs. Preferred residential areas are on the high terrain, while working class residences and commercial properties are on the lower alluvial land along the banks of the Tietê, the Pinheiros, and the Tamanduateí rivers. The population of São Paulo's urban agglomeration is a staggering 21 730 000, a figure that expanded with 664 000 since 2015.

Though 12-16% of the freshwater on the planet is in Brazil, the majority of this is in the Amazon River and northern rainforests, mostly beyond the reach of São Paulo. Instead, the city is serviced by six separate dam systems. The largest of these is the Cantareira, responsible for supplying nearly 10 million of the population.

Hydrological data dating back 84 years shows that the average water flow has been roughly 40 million L/s. The worst year on record was 1953, when annual average output dwindled to 20 million L/s. In water years 2014-2015 (running from October to September), this trickled to 10 million L/s. "What we had in 2014 was only half of the worst we had had before in almost a century," says Kelman, when interviewed by the World Bank. "We were not prepared."

Some of the first measures that were implemented aimed at curbing water use. In February 2014, SABESP launched a Water Consumption Reduction Incentive Programme, awarding those who decreased their use sufficiently. "Demand management played a very important role in drought management in São Paulo, and the tariff bonus programme encouraged the population to change their habits, adopting actions that reduced the consumption of water," says Thadeu Abicalil, Senior Water and Sanitation Specialist at the World Bank. The programme aimed to reduce consumption by 20% compared to the average recorded in the months between February 2013 and January 2014. In case of success, the customer would get a 30% bonus, even if it is within the minimum consumption range.

In November 2014, SABESP announced that the programme awarded bonuses to 53% of users and stimulated another 23% to reduce consumption without right to discount. However, 24% of users increased their consumption and exceeded the average prior to the implementation of the programme, despite public appeals by means of advertising campaigns for rational use of water amidst the notorious water scarcity.

Hydraulic scheme of the Cantareira water supply system

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SABESP then introduced a contingency fee. Customers whose monthly consumption exceeded the average with up to 20% were charged 40% of the water tariff; those who consumed more than 20% were charged 100% more of the water tariff. "The contingency tariff was applied even for clients with a firm demand contract, mostly industry and commerce," says Abicalil. Per capita consumption in the RMSP decreased from 155 liters/ person/day in February 2014 to 118 in March 2015. By July 2015, 83% of customers in the RMSP (Região Metropolitana São Paulo or, the São Paulo metropolitan area) reduced consumption, and 73% received the bonus while the remaining 10% reduced consumption without reaching the target to receive the discount. Of the mentioned 73%, 63% reduced their consumption by more than 20%, 5% reduced consumption between 15% and 20% (bonus range of 20%) and other 5% reduced between 10% and 15% and received a bonus of 10%.

SABESP also reduced volumes of non-revenue water by replacing old pipes, altering water pressure and providing guidance on the use of water meters. This led to an estimated 23% reduce in water use, amounting to 330 000 000 m^3, while the discount incentive scheme achieved a further 19% reduction in domestic use (330 000 000 m^3 per annum).

Still, as water levels dwindled, panic ensued. Decreased agricultural and industrial output threatened and ailing economy, and the hoarding of rainwater in canisters spurred an outbreak of mosquito-borne dengue. Eventually, the Cantareira system drained out, leaving the city on the brink of running empty. "I don't know what would have happened if we lost control of the water supply for 22 million people," says Kelman, who joined SABESP in January 2015, when their water stock was down to 5%. "It was only enough water for 40 days, a little more than a month. In that situation, really, tension was high."

"Demand management played a very important role in drought management in São Paulo, and the tariff bonus programme encouraged the population to change their habits."

São Paulo's near-miraculous turnabout was thanks to a combination of initiatives – including large infrastructure projects, an intense programme to reduce water losses, and eventually, rain. SABESP footed majority of the bills, with some loan financing by the Federal Government and the International Bank for Reconstruction and Development (IBRD). Projects that were prioritised included connecting systems that still had capacity (the Billings reservoir, the Rio Pequeno, and the Rio Grande) with pipelines to treatment stations (the Taiacupeba water treatment station). The treatment capacity of another, the Guarapiranga system, was expanded from 14 to 16 million L/s within a couple of months with the use of ultrafiltration membranes.

Then, it started to rain. Ironically, downpours in February 2015 wreaked havoc, causing widespread flooding across the city, but falling beyond the reach of the main reservoir 60 km away. Still, at the end of the rainy season in March 2015, storage capacity was at 15%, and by February 2016, water levels at the main reservoir have more than doubled.

The megacity of São Paulo, in Brazil, had less than 20 days of water left for the near-22 million population during the height of drought in 2015.

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The Pinheiros River is one of the rivers feeding the city.

"São Paulo's near-miraculous turnabout was thanks to a combination of initiatives – including large infrastructure projects, an intense programme to reduce water losses, and eventually, rain."

Building a more resilient future

Many measures adopted during and after the crisis, on both demand and supply side management, increased the water reliability of the metro area, says Abicalil. "The São Paulo metropolitan area is now a more resilient city for droughts."

On the supply side, three large structural projects are set to add a further 13 million L/s to SABESP's drinking water production capacity for the Metropolitan region. The Sao Lourenco public-private partnership (already underway when the crisis hit) will deliver treated water to the western Metropolitan Region. The almost R2 billion Jaguari-Atibainha project will connect the Paraiba do Sul basin to the Piracicaba, home of the Cantareira system. The third will divert water from the Itapanhau River, which flows into the Atlantic.

Still, SABESP (literally) paid a high price for their success. In addition to the funding of large-scale infrastructure investments, the company's financial stability was severely impacted by the reduced water use of domestic customers. Net profit fell by almost two thirds from 2014 to 2015 and water and sewerage tariffs were increased with 15.2% to recover some of the investment made thereafter.

Tough questions remain regards the payment scheme for bulk water, the bonus and contingency fee scheme demonstrated the importance of demand management and the elasticity of price, says Abicalil. Questions include whether water rights and bulk water charges should be implemented for all users (urban, industrial, agriculture, energy, transport) as a comprehensive instrument for water management; if in case of scarcity, a compensation scheme should be designed to upstream water users by downstream water users; or, if high-value and priority users such as urban residents should compensate for non-priority uses, such as agriculture.

Abicalil points out that although São Paulo is more resilient to drought, water security also relates to other extreme climatic events that the city is vulnerable to, such as floods in the summer season. A third dimension of water security that SABESP is working hard to improve relates to water quality of rivers and in reservoirs.

In sum, a water secure future for São Paulo lies in an integrated approach to urban water, says Abicalil - one that goes beyond merely looking at the resilience to drought, and the reliability of water supply.

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20 lessons from São Paulo

(supplied by Thadeu Abicalil, Senior Water and Sanitation Specialist at the World Bank, Prof Francisco da Assis Souza from the Federal University of Ceará and Carmen Molejon Quintana, Water Resources Specialist of the World Bank)

1. **Drought is a socio-natural phenomenon and management requires action in different arenas:** Actions in the arenas of public opinion, political-institutional and judicial, as well as technical solutions should aim to mitigate conflict and work towards sustainable decisions from technical, social, political and institutional points of view.
2. **Rules for allocation and rationing should be decided on before the drought,** together with social parties involved.
3. **Set rules for public participation before the onset of drought:** Public participation is important for legitimacy and social integration but defining the rules and framework for this process during the crisis is not sustainable, and arbitration of conflicts during the crisis without pre-defined rules can be extremely challenging.
4. **Drought management requires different expertise for sustainable solutions:** Water resources systems are complex socio-natural systems, and decisions must be supported by legitimate and relevant knowledge across social, economic, political, climatic, ecosystem, and engineering dimensions.
5. **Water systems are complex and should be analysed as an integrated whole:** All role-players must recognise that there are competing uses and benefits involved. Modelling must be applied to analyse the system and incorporate future uncertainties.
6. **The operational management of drought requires agile and continuous decision-making processes:** Response time to changes is a decisive factor in the quality of drought mitigation response.
7. **Technical expertise is essential:** The technical quality of the organizations that manage and operate the system is a decisive factor in the management of droughts.
8. **Water systems' vulnerabilities to droughts can be mitigated by relatively small interventions in hydraulic structures:** Actions such as the adjustment of water intake characteristics to ensure submergence level for pumps can significantly relax the operation of hydro-systems.
9. **The actions of drought management should incorporate actions of supply management, demand management and conflict management.** For supply management, operational flexibility of the system is the golden rule (ranges of pressure variation; sectorization of the supply network; redundancy with possible supply by different sources). Economic incentives (tariff or bonus) should be analysed in conjunction with other behavioural change strategies in demand management. The legal-institutional framework for conflict management during drought must be built with a view to mitigation.
10. **The public prosecution process should be institutionally centralised:** Individual public prosecutions impose high costs – both to the organisation, and on a personal level to responsible technicians. A strategy that enables the continuous and centralized monitoring of the decision-making process by the control bodies, especially the Public Prosecutor, could be useful to produce a better environment for this process.
11. **Drought monitoring is essential:** São Paulo has a significant hydrometeorological and fluviometric measurement network but not drought monitoring. As the crisis developed the drought was evaluated empirically. Identifying the onset, severity and purpose of drought is essential, as early warning can go a long way towards mitigating the impacts of droughts.
12. **Establish a drought management plan before the onset of drought:** Supported by an early warning system, this will result in reduced impact of drought by identifying necessary measures in advance for each stage of the drought, and necessary conditions for their implementation. During crises, previously viable resources might become unavailable, and their cost can increase significantly due to their necessity at short notice.
13. **Coordinate and integrate water management institutions for successful drought management:** An institutional framework for the physical, political, institutional and social spheres should be built to coordinate actions. Planning and definition of roles should be completed before the drought.
14. **The definition of permissible risk is a fundamental criterion for projects that promote water security and must be established with social legitimacy:** Water resources systems are designed to provide a guaranteed supply of water. The risk of shortage is defined by the likelihood of the occurrence of events more severe than those of the project value. Usually, a 90% guarantee of supply is used as reference, with a 10% probability of failure. This definition of hydrological risk does not explicitly consider damage. Systems for human supply should provide for the lowest probability of failure, though this implies higher deployment and operating costs.
15. **Political disputes between regional interests and world views must find institutional shelter for their arbitration in the water management process:** For Sao Paulo, space for mediation is made possible by the SIGERH (sistema integrado de gestão de recursos hídricos) with support from the Law of the Waters.
16. **A communication plan to inform public opinion is of great importance:** Conditions for transparent communication should be defined by institutions, to prevent opportunistic individuals or entities from gaining recognition and social standing through the creation of noise and using half-truths. Though multiple interpretations of events are legitimate, and inherent to democracy, these must occur within the stipulated public participation space.
17. **Drought planning must include financial mechanisms for reduced income:** During the crisis, the amount of water distributed and billed for by companies reduces significantly, with a concurrent impact on the sustainability of integral organisations such as sanitation delivery companies.
18. **The role of the water grant should be defined:** Is this an administrative instrument for authorizing water use, or does it play a role in defining broader public policies? The role of water policy must also be understood – whether it guides the water sector, guides other public policies, defines only the role of agencies in the water sector or further beyond.
19. **Consumption patterns and beliefs are forever changed:** The period of water scarcity impacts the water conservation habits, but the social fabric of the city was distorted during the drought, and there is no return to pre-drought conditions. This is a positive result, but temptation to return to pre-drought levels of consumption must be tackled.
20. **A drought governance system is key:** Drought management must take place in different arenas (technical, political, public opinion, legal) and requires technical expertise to deal with inherent complexity and uncertainty, institutional mechanisms for conflict arbitration, supply management that promotes efficiency, and efficient and equitable demand.

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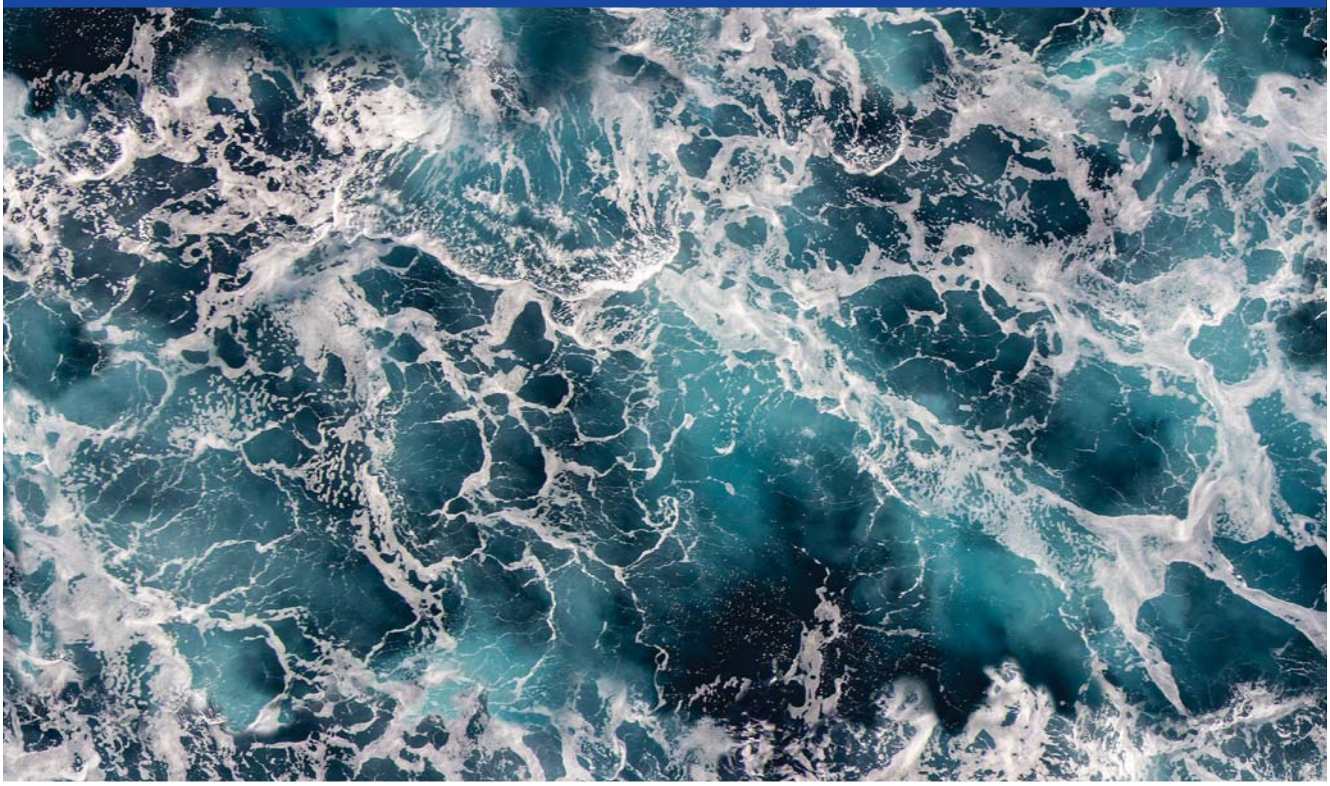
SEAWATER DESALINATION

Seawater desalination – what difference does site choice make to cost?

There are various factors to consider when selecting desalination as an alternative water-supply option. The selection of a suitable site may be the most important contributing factor to the cost of a large-scale seawater desalination plant. This is according to Dawid Bosman of TCTA.



Seawater desalination holds a tantalising value proposition for coastal cities: An infinitely scalable supply of assured water, at a predictable price, which effectively de-couples water security from the climate. Such drought-proofing already serves many cities around the world; more than 160 seawater desalination plants with a capacity beyond 50 Ml/day are on-line, providing assured water to local authorities in Spain, the Middle East, Australia, the USA and others.

Given the extent to which South Africa's natural water resources have already been committed, it is likely that large-scale desalination will be adopted by some of the coastal metros, probably within a five-year timeframe. From a national perspective, it is an opportune time to learn from the project implementation experiences and practices of other nations. The Trans-Caledon Tunnel Authority (TCTA) has, over the past few years, been observing the desalination implementation lessons from abroad, in anticipation of the first desalination mega-project on home ground.

One of the early observations has been that the capital cost of these plants can vary significantly: Among a benchmark group

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of more than 200 similar projects (all extra-large scale seawater reverse osmosis plants, or XL-SWRO), the specific capital cost ranges from as little as $200 per m^3 per day capacity, to more than $3 600, with the 25th and 75th percentiles spanning from $800 to $1 400. As a general rule of thumb, an XL-SWRO plant should cost in the vicinity of $1 000 for every kl/day capacity. Taking into account operating cost within normal parameters, the product should cost in the vicinity of $0.60 to $1.20 per m^3. The benchmark costs are expressed in US Dollar, for ease of comparison.

This leads one to the question: What are the factors contributing to an XL-SWRO project being relatively more expensive than others, and how can this be managed? Expensive water is a political hot potato, and more so when it could be blamed on the adoption of a new technology, even when a drought made that decision unavoidable; that has been one of the key lessons emanating from the Australian desalination build programme of 2006 to 2012.

While there are multiple factors that influence the capital cost of desalination plants, this analysis suggests that site selection is perhaps the single most important contributing factor, to the extent that it may pre-determine a number of very expensive design options.

"Expensive water is a political hot potato, and more so when it could be blamed on the adoption of a new technology."

Site considerations for large-scale desalination plants

Large-scale seawater desalination requires the continuous abstraction of a large quantity of consistent quality seawater, the delivery of this feed-water into a high-pressure industrial process plant, where energy will be used to separate some of the volume as freshwater, with the remaining portion returned to the sea as brine. The cost and environmental impact of this endeavour is significant, and can become daunting if it is not planned and executed with great care.

The site chosen to place this operation is extremely important, and the impact of this choice will allow or constrain subsequent design options, construction methods and operational efficiency. If the chosen site will cause construction to infringe upon a pristine beach or a sensitive wetland, or cause a noise or visual disturbance to a residential area, or the abstraction of feed-water and release of brine will exceed regulated limits in the marine environment, then the developer would be compelled to mitigate those impacts, normally through adjustments in the plant design. Invariably, this leads to higher cost.

However, a site that could avoid some or all of these impacts, will usually allow easier permitting, bring less pressure on the developer to select expensive design options, and allow easier integration with pre-existing infrastructure. Considering the XL-SWRO projects completed during the last decade, it would appear that the choice of site determined subsequent capital cost mainly in two areas:

- The **marine works**, where the design options of the intake and outlet structures may be determined by the site topography, the adjacent land use or environmental sensitivity;
- The **plant architecture**, where visual and noise impact on affected parties and nearby settlements, during construction and thereafter, need to be mitigated through design modifications.

Marine works

The marine works is a key element of the capital outlay of a desalination plant. These structures generally appear over-designed, and much larger than one would intuitively estimate they should be. This is due to two reasons, firstly, that the RO process recovers only about 40% by volume of the feed water as permeate or product water, and hence the intake pipe needs to also accommodate the 60% that will return to sea. Secondly, the fluid velocity in the intake pipe must be sufficiently low, in the range of 0.05 to 0.1 m/s, to avoid any marine life entrainment. This requires large-diameter structures, in general.

The marine works is usually either a trenched pipe or a jacked pipe design, which are generally cost-effective, or a tunnel design, which tends to be much more expensive. The choice of site will largely determine which construction method could be followed. The DesalData costing model indicates that by selecting a tunnel design, instead of a trench design, the cost of the marine works increases by 200%, and total plant capital expenditure increases by about 30%; directly through more complex construction, and indirectly through greater legal and design costs (Global Water Intelligence, 2018). Brief descriptions of the two designs will help to illustrate why tunnelling is much more expensive.

A trench design can be usually be followed when the site is not significantly elevated above sea level, and with direct access to a sterile beach. Typical construction comprises a trench dug towards the beach with pile-driven steel sheets as reinforcement, in which large-diameter HDPE pipes are laid. Through the surf-zone and out to sea, the pipe is laid in a sub-surface trench, which may be protected by a temporary steel jetty, as required by local conditions. Figures 1 to 3 shows some of the trench design elements during construction.

Tunnelling is usually required when:

- The site is situated some distance inland from the beach, and other developments block its access to the sea (an example would be the Gold Coast Desalination Project);
- The beach is in recreational use, or ecologically sensitive, which would be impacted by a trench (An example would be the Southern Desalination Project);
- The site is on a raised coastal ledge, which requires an engineering solution to access and lift the water to a higher elevation (An example would be the Adelaide Desalination Project).

Compared to a trench design, a tunnel design is much more complex. Figures 1 and 2 below show cross-sections of the intake and outlet structures, in this instance of the Adelaide Desalination Project (Note the elevation of the plant, some 52 m

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above sea level). In the first phase of construction, typically, a 10 m diameter shaft will be sunk, about 50-60 m deep, depending on the depth of competent rock found by the geotechnical survey, and the depth required to create a wet well. Then a Tunnel Boring Machine (TBM) will be lowered into the shaft, and commence boring out to sea, lining the tunnel with concrete segments as it progresses. Due to the requirement to abstract seawater at a depth of 20 m or more, and the need to disperse brine over a large area in deep water, the intake and outlet tunnels could extend well beyond a kilometre, depending on the gradient of the sea floor.

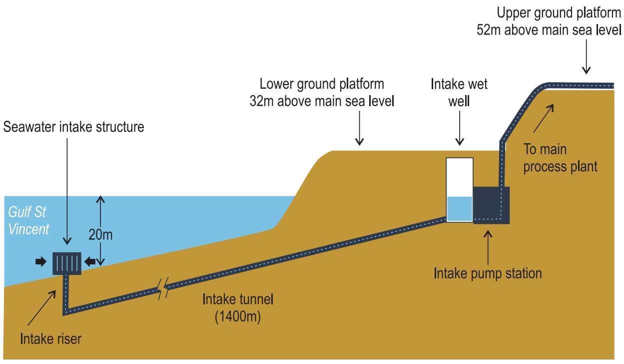

Figure 1: The intake tunnel structure of the ADP. Note that the diagram is not drawn to scale (Aurecon Group).

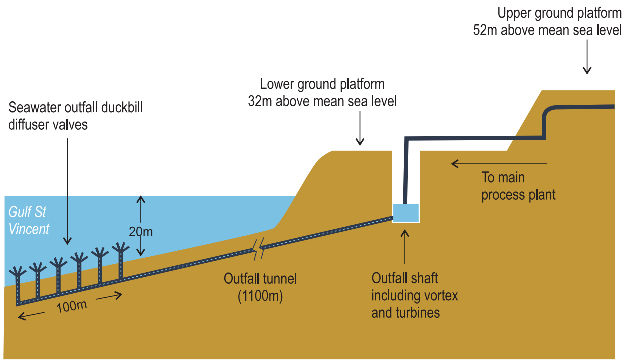

Figure 2: The outfall tunnel structure of the ADP (Aurecon Group).

From the above description and illustrations, one could intuitively deduce that a tunnel design should be significantly more expensive than a trench design, all other aspects being equal.

To determine how the choice of marine works or co-location corresponds with actual outcomes, 16 XL-SWRO projects were randomly selected, and compared in terms of their specific capital cost. Given that each project is unique, the limited sample analysed, and that capital cost is influenced by other factors beyond the marine works, this comparison is largely for illustrative purposes:

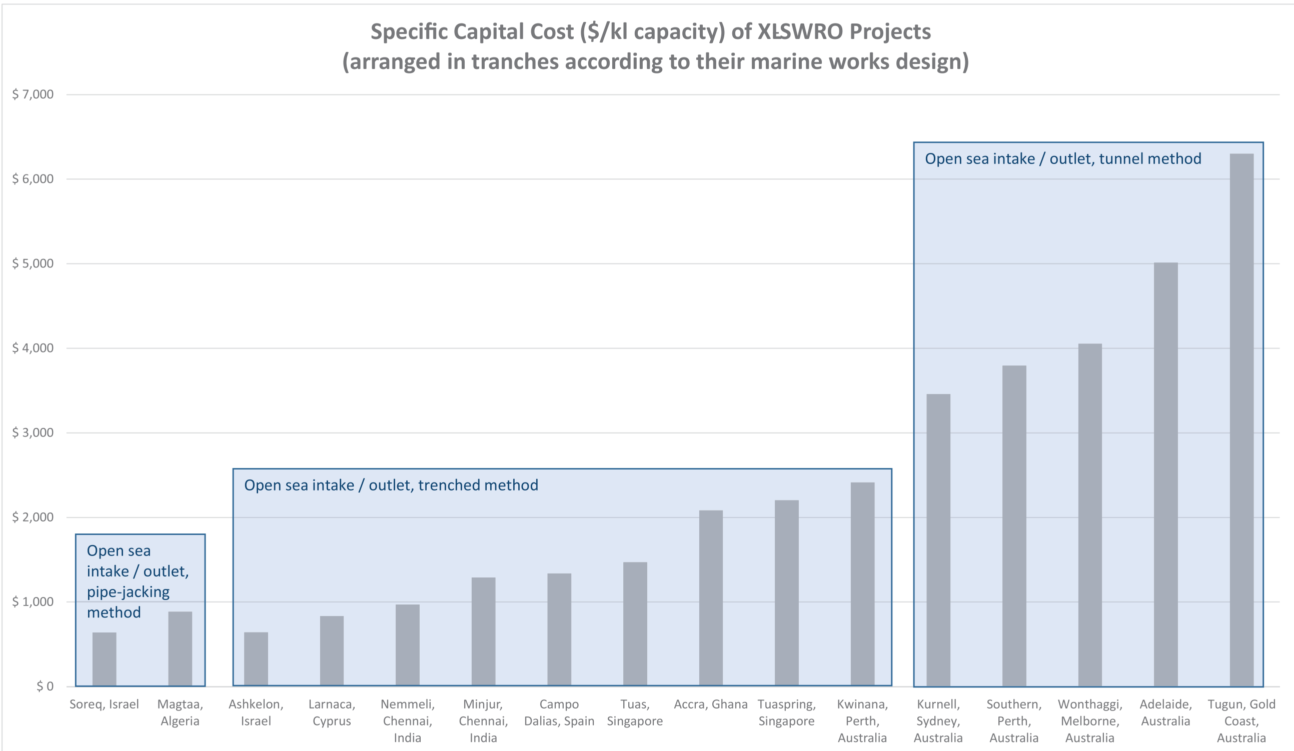

Figure 3: A comparison of the specific capital cost of large-scale seawater desalination projects (Data sourced from www.DesalData.com, www.desalination.biz and www.water-technology.net)

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It would appear that XL-SWRO projects with trenched or pipe-jacked marine works are generally more cost-effective than projects with tunnels.

Plant architecture

Desalination plants are more likely to compete with existing land users for space than most other types of infrastructure. It yields a high-value product which is ready to be consumed by the end user, but expensive to convey over distances. Hence, practical and economic considerations argue for these plants' location in close proximity to urban concentrations. Simultaneously, desalination plants require a site at the sea, or very close to it, to be cost-effective. As a result, it is not uncommon for a planned desalination plant to be challenged by other land users on the basis of real or perceived infringement on nearby settlements, or by ad-hoc recreational users of the impacted land. In most instances, the developer will revise the plant architecture to the extent that the impact is sufficiently mitigated, unless the cost of such mitigation brings a secondary site option into consideration.

Co-location with a power plant

Should the option exist of placing an XL-SWRO plant adjacent to a water-cooled coastal power plant, the advantages could be very substantial to the desalination facility, and the viability of this site should be explored. The benefit of such co-location could be much more than the convenience of a close-proximity power supply, provided that the marine infrastructure of the power plant could be shared.

Co-location has several benefits: 1) The desalination plant obtains its entire feed water supply from the condenser cooling cycle of the power plant, thereby eliminating the need for an expensive seawater intake structure. This saves at least 5-20% on capital cost. 2) With no need to construct a seawater inlet structure, disruption of the marine benthic zone during construction is avoided. 3) Since the cooling water from the condenser is about 10ºC warmer than the ambient sea water, having had some heat transferred into it, the RO process requires 5-8% less pressure for salt exclusion, resulting in a commensurate power (and cost) saving (Bear in mind that energy typically comprises about 30% of the product cost). 4) The highly saline brine released from the RO process is diluted by a much larger stream of seawater, before being released into the sea, resulting in highly cost-effective brine dispersal. 5) The thermal impact of the power plant on the marine environment is reduced, due to some of its heated outfall water being converted into potable water.

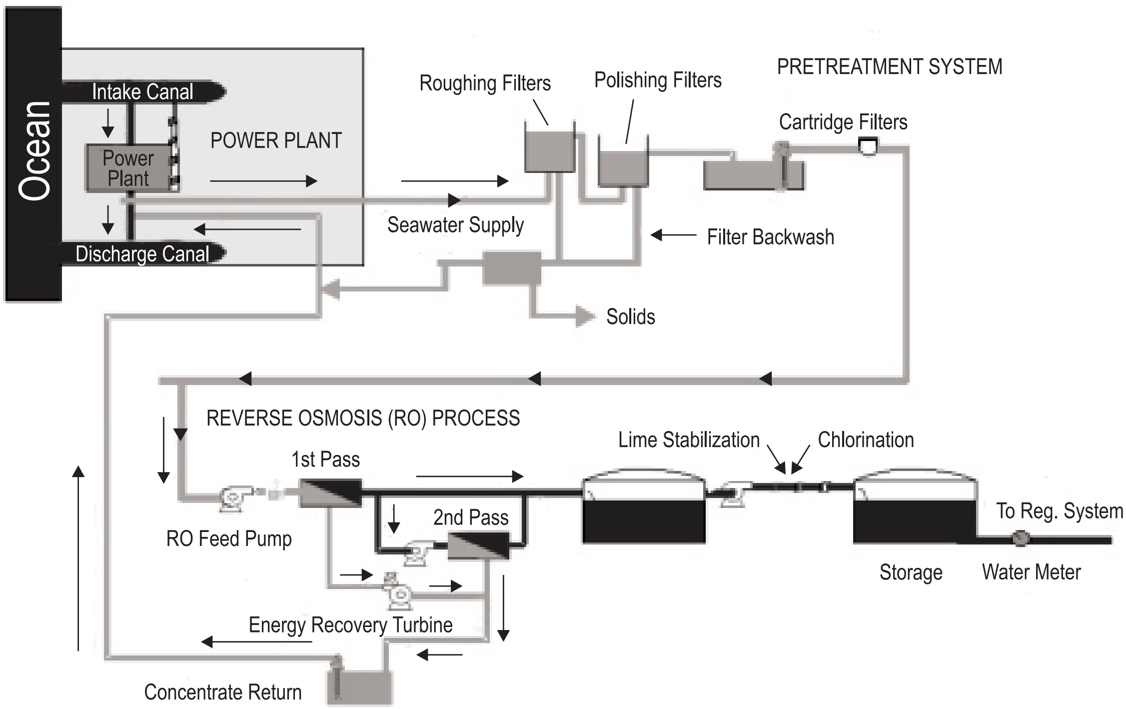

Figure 4: A schematic illustration of co-location of a power plant and a desalination plant (Callahan, N).

Considering the viability of co-location in the long term, there are a few challenges to consider. Foremost is matter of technology lifecycles: Co-location requires two distinct technologies (i.e. thermal power generation and reverse osmosis), which are in different life-cycle phases, to become inter-dependent through shared infrastructure. Should thermal power generation, or simply the design of the pre-existing power plant become redundant, or its cooling technology be replaced, then the desalination plant will lose significant advantages. At a minimum, this would require additional infrastructure to pump and screen the raw seawater, RO process modifications, and the construction of an outlet pipeline and brine diffuser. It is therefore a good practice to require that the feasibility of both plants be demonstrated independently, on a freestanding basis, as a prerequisite for co-location.

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Site selection process

The process of selecting a site requires thorough analysis, but it also involves the anticipation of environmental and societal responses, which can make it more iterative than linear in character. Site selection, as a field of study and practice, evolved mainly during the 20th century in the USA, and has remained largely unchanged in its approach and method: Project needs are matched with the merits of potential sites, followed by an elimination process, and in-depth analysis of a short-list of sites.

The site selection for large desalination projects follow the same approach, but the unique criteria and requirements make it a specialised discipline. Once a short-list of perhaps three to five sites have been identified, specialist consultants would typically be retained to conduct a detailed due diligence of each site, which could include study elements such as geotechnical assessments, marine biological assessments, extended environmental screening and seawater characterisation.

For each of the short-listed sites, the following considerations would be explored, and where possible, its impact quantified over the project life cycle:

Logistical considerations:

- The plot size should be adequate to allow for up-scaling of the desalination plant, and for the safe on-site storage of chemicals. A size of 20 ha is usually adequate for an XL-SWRO of 150-300 Ml/day capacity
- Proximity and unobstructed access to the shoreline
- Ease of integration with the existing water grid
- Proximity to the power grid infrastructure. A 150 Ml/d plant typically requires a 132 kV single source supply, and draws 22-25 MW of power under full production
- A site already owned by the implementing agency has a distinct advantage, as it could avoid sensitive and drawn-out purchase negotiations

Sub-surface geotechnical considerations (especially when tunnelling is required):

- Assessment of subsurface conditions, both onshore at the plant site, and offshore along the route of the intake and outlet tunnels

Marine considerations:

- Seabed conditions, as determined by a bathymetric survey
- Seawater currents, from which brine plume dispersal could be modelled. The rapid dispersal of brine in sea water is desirable, from an environmental perspective. Due to the salinity of brine being higher than that of the ambient seawater, and therefore has a higher density, the brine will tend to settle on the sea bed, and cause harm to the marine fauna and flora in the benthic zone. A sustained level of sea current is therefore desirable, to help with the dispersal of brine. A site with restricted or inconsistent ocean currents could encounter permitting delays, onerous monitoring requirements and even periodic plant shut-downs, when brine concentration limits have been exceeded.
- Long-term seawater characterisation: The quality and temperature of feed water has a significant impact on the pre-treatment process design and power consumption in the RO process, and hence influences capital and operational cost. Sampling should continue for at least a year, to allow for seasonal variation. Certain feed water qualities may be site-specific, and determined by the localised impact of storms, sea currents or the proximity of pollutants.

On-shore environmental considerations:

- Prior use of the site: A previously disturbed site can be attractive, as it often presents a lower environmental hurdle.
- Current and future use of the adjacent sites, and the wider precinct. A site within an industrial precinct can be advantageous;
- Ecological sensitivity of the site and adjacent area;
- Proximity and line-of-sight to human settlements;
- Existing recreational utilisation of the beach area.

Once the costs and benefits associated with each of the above considerations have been quantified, as well as the timeframe in which it is likely to occur, the Net Present Value (NPV) of cash flow associated with each can be calculated. Whilst allowing for key considerations that could not be quantified, the site with the lowest NPV would usually be selected.

Concluding remarks

Choosing a site for a large-scale seawater desalination plant is a complex matter, which requires many considerations to be quantified and considered. The cases presented here, suggest an element of causality between the site characteristics, and the subsequent design options and their cost implications. It is therefore advisable to follow a rigorous and systematic approach of short-listing, analysis and selection.

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SCHOOL SANITATION

School sanitation – Returning dignity to South African schools

The school sanitation management model developed as part of a Water Research Commission (WRC) funded project has been piloted and refined. The model is part of a suite of tools towards truly sustainable management of school sanitation in South Africa. Article by Sue Matthews.

The tragic death of Lumka Mketwa, the five-year-old girl who drowned in a pit latrine at an Eastern Cape school on 12 March, has prompted a renewed uproar about the state of school toilets, a little over four years since Michael Komape suffered the same fate a week after starting school in Limpopo.

President Cyril Ramaphosa reacted by giving Basic Education Minister, Angie Motshekga, a directive to conduct an urgent audit of unsafe structures at schools – particularly ablution facilities – and come up with a plan to fix them within three months. This had in essence already been done, because the National Education Infrastructure Management System (NEIMS) report for January 2018 indicates that 8 702 schools countrywide have pit latrines, which are 'not allowed at schools' according to the Norms and Standards for School Infrastructure regulations, published in November 2013. Although most of these schools have other types of toilet too, 1 426 of the Eastern Cape's 5 393 schools have only pit latrines (37 are reported to have no sanitation facilities at all), and a similar situation exists in KwaZulu-Natal.

In terms of the regulations, the provinces were given a year to draw up plans indicating how they would meet the Norms and Standards by the end of November 2016, and when

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New basins installed prior to the start of the pilot programme had ready-made hole for taps, but wall-mounted taps were fitted instead. These do not extend far enough over the bowl, so water falls onto the basin ledge and then through the holes, creating large puddles on the floor. The contractor painted the walls and doors but then left behind the used paintbrushes, which learners used to daub paint on the newly renovated facilities.

that date came around they submitted progress reports on implementation. These documents have been used to guide expenditure of the Accelerated Schools Infrastructure Delivery Initiative (ASIDI) funds administered by the National Department of Basic Education, and the Education Infrastructure Grant made available to the provincial departments.

Minister Motshekga nevertheless convened a Council of Education meeting on 21 March with provincial education ministers, department heads and officials responsible for school infrastructure, and subsequently issued a media release about the agreed way forward.

"One of the big challenges that affects roughly half of the schools that are still reported to have pit latrines is that alternative ablution facilities have been constructed, but that the old pit latrines still remain," she noted. "We already have an existing plan in place that is intended to eradicate these unsafe and inadequate toilets. We need to confirm the information we already have and fast track our existing plans. Our priority is safety."

Unfortunately, the most common alternative to pit latrines in the Eastern Cape, KwaZulu-Natal and Limpopo are so-called 'VIP toilets' – ventilated improved pits – which also pose a safety hazard if they are damaged or not properly maintained. A broken floor, unstable pedestal or loose seat could cause a learner to fall into the pit below.

As part of an earlier WRC-funded study (K5/2381) to investigate the factors contributing to the failure of on-site sanitation at rural schools, Pietermaritzburg-based firm Partners in Development (PID) developed guidelines for building and managing school toilets (**Report no. TT 698/16**). Ways of making VIP toilets safer were suggested, such as adding parallel bars below the pedestal, putting handles on either side of the toilet seat, offsetting the pit behind the pedestal, and providing lower toilets with smaller holes and seats for younger learners.

It was emphasised throughout the guidelines, however, that without proper management any new or renovated sanitation facilities could quickly revert to an unsafe state – which not only encompasses the risk of falling into latrines, but also the health hazards posed by filthy, unhygienic conditions and the threat of bullying, assault or rape. All learners have the right to health and safety, as well as dignity, so their need for privacy should be respected too.

The PID project team therefore proposed a model for managing school sanitation effectively in the final chapter of the guidelines, and also produced an accompanying management handbook. They recently completed a follow-up project to pilot these outputs in eight schools in the Vulindlela area of Pietermaritzburg, following a selection process and renovations by the KwaZulu-Natal Department of Education.

The management model relies largely on a sanitation team at each school made up of the principal, a teacher acting as a Health and Safety Manager (HSM), and a cleaner or Health and Safety Officer (HSO). The concept was designed to ensure a chain of accountability and communication, and roles and responsibilities were outlined at the start of the programme. In

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addition, training was given on disease transmission, suitable cleaning techniques, and methods for reporting and monitoring work. Supplies were provided, and their usage was assessed on a monthly basis. Apart from regular visits to each school, interviews were conducted with the sanitation team members every month or two, and with a group of learners mid-way through the pilot programme and after its completion.

Four main aspects were assessed in the pilot programme – supplies, the cleaning protocol, monitoring and reporting, and oversight of learner behaviour.

Supplies

Most of the cleaners were not using a bleach product before the pilot programme, which meant they were unlikely to be effective at killing germs. They were therefore informed of the importance of using bleach to clean taps, handles and toilet seats, and any other sites contaminated by faeces. Unilever donated its bleach product Domestos for the programme, as well as the soapy cleaner Handy Andy for mopping floors and cleaning other surfaces. Typical usage during the programme indicated that schools should budget for 4 litres of bleach cleaner per month, and 5 litres of soapy cleaner.

Half a roll of toilet paper per learner per month should be sufficient, but careful consideration needs to be given about how best to make this available to learners. Leaving toilet paper in the ablution blocks inevitably means that some of it is taken home, but if it is given to teachers for safekeeping they must ensure learners are aware of this and feel comfortable asking for it.

The project team also delivered 25 litres of liquid hand soap per month to each school, but usage was low, because the dispensers were either broken or were not filled when they ran out of soap. If these obstacles are overcome, 25 litres should be enough for 500 learners, or bar soap made available instead.

Apart from these consumables, cleaning equipment such as mops, buckets, wiping cloths and toilet brushes would be needed for a successful school sanitation management programme, and the HSO should be provided with protective gloves, boots, overalls and masks – all replaced at varying intervals. A dose of deworming tablets for the HSO every six months should also be included in the budget. All of this adds up to a total estimated cost of R10 195 per year, which for a school of 500 learners works out at only R20 per learner. This cost could feasibly be covered under the Norms and Standards funding that schools are allocated as a contribution to running costs, but most schools lack the ability to set aside that funding – plus the disbursements are often late, which hampers planning and results in consumables running out.

The project team did not include sanitary pads in the budget as they are being supplied to just under a million learners at KwaZulu-Natal schools by the provincial Department of Education. At the end of March, news reports revealed that the Department had dramatically inflated its budget for this, and there was a huge oversupply problem, with some schools having so many pads that boys were using them as shin guards when playing soccer! It subsequently emerged that the department had spent R40 million on sanitary towels in the 2017/18 financial year, almost as much as the R60 million required to implement the entire sanitation programme outlined above at all of the province's 5 840 schools.

Cleaning protocol

The pilot programme's recommended cleaning frequency in school toilets was three times per day – once in the morning and then after each break – but this could not be achieved. Originally, the Department of Education had agreed to appoint an EPWP worker at each school to clean and monitor the toilets, but this arrangement fell through. The HSO role was therefore undertaken by the schools' existing cleaners, and the cleaning frequency differed from school to school according to the cleaners' willingness. Those who were flexible and recognised the need for regular toilet cleaning thanks to their new-found knowledge on disease transmission were able to adjust their cleaning rosters so that the key disease hotspots were cleaned daily. Some of them noted that the job got easier and easier the more regularly they did it.

At one school, however, the cleaner flatly refused to clean the toilets, claiming it was not part of her job, and since the school did not have a copy of her job description, no action was taken. Yet the Department of Education's standard job description for school cleaners has ablution facilities at the top of the list of locations where cleaning duties must be performed, followed by offices, boardroom, staff room, stores, visitors' rooms, furniture, kitchen, and waste removals. Most cleaners also spend much of

Boys will be boys so active monitoring and awareness of their behaviour is a vital part of any school sanitation management programme. In this case of mischief-making, beans from the previous day's feeding programme had been poured into the urinals and basins, and strewn all over the floor.

A Partner in Development fieldworker shows school cleaners how to use the administrative forms developed for the sanitation management pilot programme.

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their time cleaning classrooms and verandas, even though these aren't listed in their official job description. The cleaning activities are no doubt largely influenced by the principal's requirements.

"The HSO cannot be able to clean the toilets daily," said one principal during an interview. "If it would be so, it would mean that she would need to sacrifice some of her other duties and not clean maybe the offices and so on."

Clearly, though, offices are a low priority in terms of their potential for disease transmission, and may only need to be cleaned once per week. Learners could even be tasked with cleaning their classrooms or sweeping verandas, perhaps through a roster system, but should never be made to clean the toilets as it puts them at risk of disease.

Monitoring and reporting

The teachers' envisaged role as Health and Safety Managers (HSM) was to monitor the sanitation situation on a daily basis, discuss any issues with the HSO, and report problems to the principal. They were meant to sign a daily cleaning checklist filled out by the HSO, and complete a weekly sanitation infrastructure inspection form. The forms were not used as intended, however, and in some cases the HSMs either did not visit the toilets every day, or did not communicate with the HSO or principal. This was often due to interpersonal issues, feelings of powerlessness, or simple conflict avoidance.

"To the cleaner, it seems like you want to boss him/her around, while he knows the principal to be the boss and only the principal can give him orders," noted one HSM. "Then as a teacher I am afraid to communicate with the cleaner. I have to go to the principal to report. It is the principal who will then have to take action, maybe call the cleaner to have a talk about the reported situation in the toilets. At the same time if the principal does that another challenge arises because to the cleaner you seem like a spy. That is the challenge we face in terms of communication."

Some HSMs did play an active role, however, and provided moral support to the HSO, talked about toilet etiquette at school assemblies, or got learners involved in monitoring and reporting the condition of the ablution facilities – or other learners' behaviour in them.

Oversight of learner behaviour

The PID project team point out in their final report that the behaviour of learners in the toilets will impact the effectiveness of sanitation management, even if a school has all the proper supplies, protocols and structures in place. "If the learners are not properly monitored and disciplined, a cleaner's work in the toilets can be negated within moments by destructive behaviours," they state.

Apart from urinating or defecating on the floor, learners often engage in deliberate acts of vandalism, or mere mischief-making.

"They threw toilet papers out of the windows; the whole school is filled with them," reported one HSO. "Woo! I have to pick them up every morning. They come to me and ask for them, and then I give each class rep. The next thing you know, rolls and rolls of toilet paper are all over the school, on trees, when it's windy they are blown all over and I have to pick them up. There are those who blow their noses and throw it out the window."

In this case, the school responded by discontinuing distribution of toilet paper to the classrooms. Learners now have to go to the office to request toilet paper, and it is likely that many just do without, or have reverted to using scrap paper or textbooks.

The project team stress that it is vital for the school's sanitation team to develop a strategy for keeping learners' behaviour in check, ideally involving both learner reporting and active monitoring by staff.

Model refinements

Based on their findings from the pilot programme, the project team have refined the sanitation management model and changed a number of aspects. For example, roles and responsibilities have been more clearly defined, the forms are being revised – they will now comprise an easily completed daily cleaning checklist, a log of sanitation problems, a weekly supplies inventory and a monthly infrastructure inspection sheet – and the cleaning protocol has been adjusted so that contamination hotspots are cleaned every day, while floor-mopping and other tasks take place at least twice per week. New tools have also been developed to educate learners and assist with sanitation management planning.

The project team has recently started working on a larger pilot programme being implemented in 100 schools in KwaZulu-Natal and 50 in the Northern Cape, in partnership with Unilever and the Department of Basic Education. If all goes well, it's hoped that the model will be adopted and rolled out to schools throughout South Africa, combined with appropriate training for HSOs and principals, and tools to support school governing bodies (SGBs) in budgeting for sanitation.

Failing that, the project team urge SGBs and education officials at all levels to play a more active role in enforcement and support functions to achieve truly sustainable management of school sanitation. Ensuring that monitoring and maintenance is routinely undertaken will not only cut down on costs for new infrastructure, but also protect learners' rights to health, safety and dignity.

The HSO workshop at the end of the pilot programme closed with 'thank you' gifts for all the school cleaners who took part, as well as trophies for those receiving special recognition.

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WETLANDS

Municipalities receive support to manage their wetlands

ICLEI's Local Action for Biodiversity: Wetlands SA project is drawing to a close, having achieved great success in encouraging municipalities to value and protect their wetlands. Article by Sue Matthews.

The acronym no longer applies, but ICLEI originally referred to the International Council for Local Environmental Initiatives. It was founded in 1990 by 200 local governments from 43 countries, who convened for the first World Congress of Local Governments for a Sustainable Future at the United Nations headquarters in New York. Given that its activities addressed broader sustainability issues rather than only environmental aspects, its name was changed in 2003 to ICLEI – Local Governments for Sustainability. Today, more than 1 500 cities, towns and regions make up this global network.

The ICLEI-Africa secretariat, based in Cape Town, hosts the Cities Biodiversity Center, which for the past few years has been implementing a wetlands project under ICLEI's Local Action for Biodiversity (LAB) programme. The LAB: Wetlands SA project, funded by the United States Agency for International Development (USAID), aimed to protect wetlands so that they can continue to provide important ecosystem services to cities within South Africa, while also increasing the resilience of cities to the impacts of climate change. It sought to achieve this by improving local government knowledge and understanding of the value of wetlands, initiating the process of integrating wetlands and ecosystem services into local government planning and decision-making, and piloting wetland projects within the participating municipalities.

The project was rolled out in nine district municipalities and two metropolitan municipalities countrywide. Starting in

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Project manager, Kirsty Robinson (front), with participants at the iLembe District Municipality's wetland strategy and action planning workshop.

September 2015, wetland awareness-raising workshops were held for each of the municipalities, with representatives from local municipalities lying within the district municipalities boundaries invited too. The participants generally included planning, disaster management and environmental officials, as well as other key stakeholders from environmental NGOs, water boards, parks boards and even traditional leaders in some cases. Representatives from Working for Wetlands, SANBI, SALGA, the Department of Water Affairs and Sanitation, and the national and provincial environmental departments attended where possible to provide additional input.

"it's all well and good capacitating the technical staff, but if there isn't buy-in from the political level you're never going to have approval for any projects or other interventions,"

The participants learned that wetlands provide vital habitat for flora and fauna, as well critical ecosystem services such as flood attenuation, water storage, erosion control, and natural filtration for improved water quality. Given that climate change is predicted to increase the incidence of extreme events in the form of droughts and floods, wetlands clearly have an important role to play in terms of both climate change resilience and disaster risk reduction. The participants were also sensitised to the threats facing wetlands, which were found to be the most threatened of all South Africa's ecosystems in the most recently published National Biodiversity Assessment. Key pressures include urban development, agricultural practices, pollution, sedimentation, and changes in water flow due to dams, water abstraction and invasive alien plants.

"During those wetland awareness-raising workshops, the municipalities all expressed a real need for information," says project manager, Kirsty Robinson. "They understood the need to do planning around wetlands, but didn't know where all the information was housed, or how to access it."

The project team therefore engaged with stakeholders to gather all the existing and readily accessible information on wetlands within the various municipal areas and collate it into a Wetland Report for each municipality. The reports were structured according to a standard Table of Contents that included chapters on wetlands and biodiversity, disaster management and climate change, governance and management, and communication and awareness. Apart from being valuable tools for awareness-raising, the reports could be used to inform initial land-use planning, identify gaps in knowledge and set priorities for wetland management.

"The next step was to address the second project objective – to initiate the process of integrating wetlands and the services they provide into local government planning and decision-making," says Robinson. "For that, we convened two-day Wetland Strategy and Action Planning Workshops for each of the municipalities."

The stakeholders came together again and – based on the information in the Wetland Reports – identified a number of focus areas as strategic priorities. Typically, these included aspects such as wetland research and monitoring, awareness-raising and capacity-building, planning and management, wetland rehabilitation, and funding. Goals were then listed for each of the focus areas, and those were further broken down into key actions to achieve the goals. After the workshops, the inputs were written up into a Wetland Strategy and Action Plan for each municipality.

"We realised though that it's all well and good capacitating the technical staff, but if there isn't buy-in from the political level you're never going to have approval for any projects or other interventions," says Robinson.

The project team therefore organised a series of Political Leaders Workshops to increase understanding of the value of wetlands among Mayors, Councillors and portfolio committee members. At the end of each workshop, the Mayors were encouraged to sign the Durban Commitment – a non-binding commitment and model to protect and enhance biodiversity at the local level. It originates from an international Local Action for Biodiversity workshop held in Durban in 2008, when it was signed by all of the 21 local governments represented.

These efforts evidently paid off, because – as of mid-April – 10 of the municipalities have incorporated their Wetland Strategy and Action Plan into their respective Integrated Development Plans. The IDP is the overall framework that ensures municipal services are provided in a coordinated way, responding to the needs of people and taking available resources into account. In essence, municipal projects cannot be funded unless they are identified in the IDP, although including potential projects in an IDP does not necessarily mean they will be funded from municipal coffers. The IDP merely informs municipal budgeting and resource allocation.

Nevertheless, as a result of the LAB: Wetlands SA project some of the municipalities have now included wetland-related work in their budgets, or demonstrated their commitment in other ways. The iLembe District Municipality, for example, has established an environmental department for the first time, while Frances Baard

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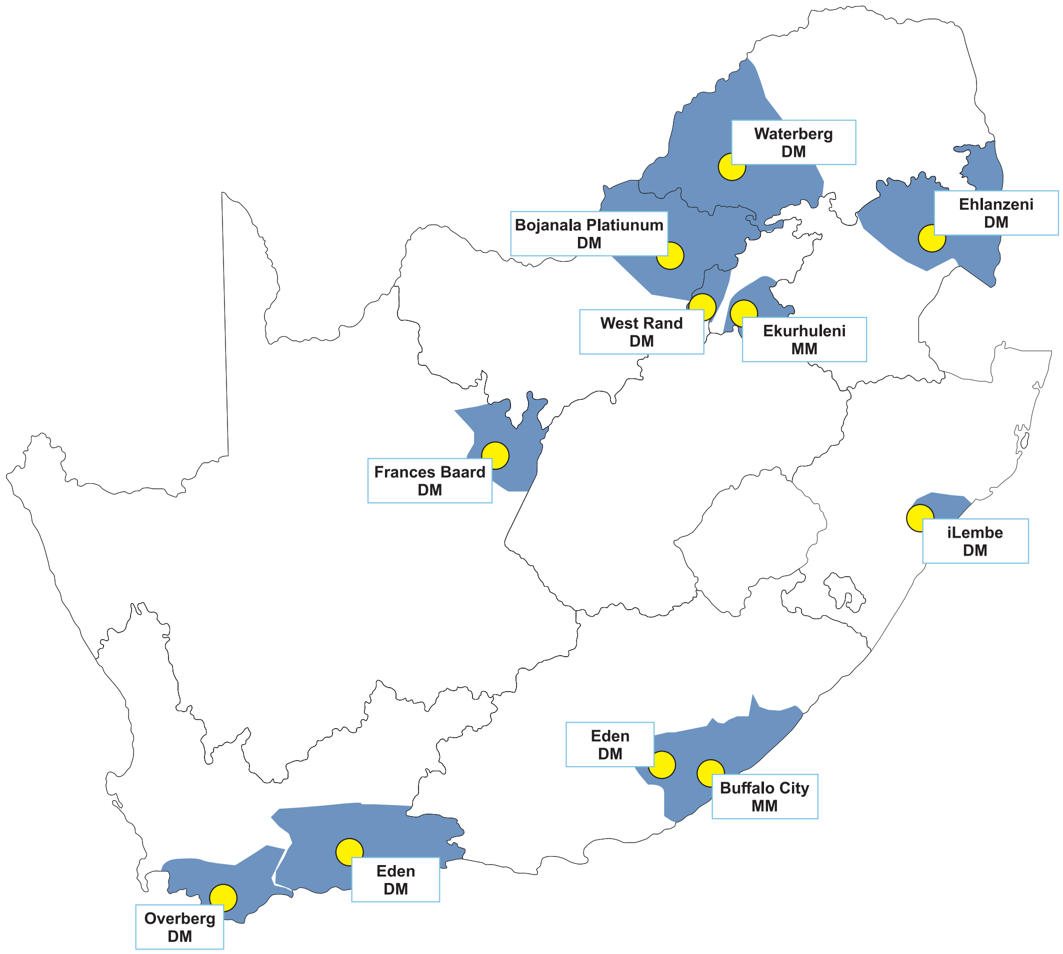

Wetland Map – The Local Action for Biodiversity: Wetlands SA project was implemented in nine district municipalities and two metropolitan municipalities across the country.

District Municipality revived the Provincial Wetland Forum and will host the 2018 Wetlands Indaba in Kimberley in October.

As for the project's third objective – to support the implementation of pilot projects – a sum of R1.2 million of the USAID funding had been set aside for this. Since that wouldn't go far if shared between 11 municipalities, it was decided to hold a competition to select three project proposals for funding. "We received 33 project proposals, which just shows how much the need was highlighted to municipalities," says Robinson. "They really wanted to do the work now that they'd seen the value of rehabilitating wetlands and doing other wetland-related projects."

The three pilot projects selected rely on consultants or NGOs with specialist expertise to perform the work within the time constraints of the LAB: Wetlands SA project, and to allow for transfer of funds with minimal red tape.

Prime Africa collaborated with the West Rand District Municipality in Gauteng to develop a detailed wetland spatial layer for the municipal area, a clear need for which had been identified in the Wetland Strategy and Action Plan. Historically, many of the area's wetlands have been degraded or destroyed through the direct and indirect impacts of rapid development and mining, yet municipal officials lacked sufficient spatial data for proper assessment of trade-offs between development and sustainable management of wetlands. Once the wetland spatial layer had been finalised, all identified wetland features were classified based on their hydrological, climatic and geomorphological characteristics, as well as their significance in the socio-economic and environmental landscape. Selected staff within the municipality were then given training to ensure the wetland spatial layer and additional information would be used for effective and informed decision-making relating to land use, zoning, building plans and new developments, and also for providing detailed input on provincial or national government processes for environmental authorisations and mining permits.

Eco-Pulse Consulting has partnered with Amathole District Municipality in the Eastern Cape to evaluate the potential for wetland rehabilitation in the district. Initially a desktop regional prioritisation exercise was undertaken, which indicated that the wetland-rich catchment upstream of Xilinxa Dam was an important area for investment as a means of enhancing the district's water security. A field trip was then conducted to assess potential sites for rehabilitation and initiate the process of wetland mapping. A report identifying priority sites for rehabilitation will be compiled, followed by the development of a detailed rehabilitation plan for one of those wetlands.

The Endangered Wildlife Trust has been granted funds to conduct a project focussing on community involvement in wetland monitoring in Ilembe District Municipality on the KwaZulu-Natal north coast. The endangered Pickersgill's Reed Frog, for which a Biodiversity Management Plan was gazetted in June 2017, is endemic to the coastal wetlands here, and is known to occur at just 25 sites. Through this project, 14 local people from rural communities have been trained as 'bio-officers' to monitor wetlands and streams in Groutville, KwaDukuza and Nyoni. An alien invasive plant eradication plan will also be developed with the aim of protecting the wetlands and providing local employment opportunities.

During the close-out phase of LAB: Wetlands SA, the project team has largely focused on developing guideline documents, as well as case studies that showcase the value the project has had to each of the municipalities.

"We're in the process of developing Wetland Management Guidelines to support municipalities with long-term management of wetlands on the ground," explains Robinson. "These are basically intended to assist the local and district municipal town planners to more effectively plan around wetlands. We're also developing a Finance Mechanism, because many of the municipal officials mentioned during the development of the pilot project proposals that they'd never done anything like that before, and weren't sure what to include. So the Finance Mechanism is designed to support the development of bankable projects and give the municipalities a better understanding of what local, national and international funders are looking for. It will include a list of currently available funding sources and their objectives, so that project proposals can be tailored accordingly."

These tools complement the Wetland Strategy and Action Planning Guidelines, completed in February 2017, to document the lessons learned from the process of developing the various Strategy and Action Plans.
"The municipalities could use the same process for other systems such as rivers, or even for sanitation planning," says Robinson. "The final thing we're doing is a training workshop towards the end of May, when we're going to bring the key municipal officials to Cape Town to train them on every tool and guideline developed within the project. The implementation project teams will also join us to share lessons learned during the pilot projects."

There is no doubt that the project has enhanced awareness and built capacity within the 11 municipalities to prioritise management of their wetlands, although Robinson notes that changes in personnel and political leadership are a major challenge. Hopefully, these achievements will translate into the full integration of wetland considerations – and biodiversity in general – at all levels of municipal planning and decision-making on a day to day basis.

Further information, as well as all the outputs of the project, can be downloaded from the ICLEI-CBC website: http://cbc.iclei.org/project/lab-wetlands-sa/

A breakaway group at the wetland strategy and action planning workshop for Amathole District Municipality.

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WATER AND FOOD

Exploring learning networks for homestead food gardening and smallholder farming

The Water Research Commission (WRC) is well known for its high quality knowledge products. The Water Utilisation in Agriculture (WUA) section has, over the years, produced valuable knowledge to guide the harvesting and conservation of rainwater to improve agricultural productivity among smallholder crop farmers and household food producers. This knowledge is useful for especially the many women farmers around the country growing crops to feed their families, and whenever possible selling excess to generate some income. However, one of the problems experienced in the field is that this knowledge does not always reach the intended audience. This is the problem that the Amanzi [Water] for Food project was engaged with. Article by Heila Lotz-Sisitka.

Household food security in South Africa remains a national challenge with an estimated 59% of 13.7 million households being food insecure. Hunger and chronic malnutrition is widespread within this group. Agriculture contributes significantly to the livelihoods of an estimated 4.5 million people who have access to small portions of agricultural land, estimated at 6-12% of household income in a rain-fed context and 21-60% in an irrigated context.

Yet, utilisation of available land water resources for smallholders (0.5-10ha), both in home-gardens and fields remain low. The National Development Plan of government and the most recent Strategic Plan of the Department of Agriculture, Forestry and Fisheries seeks to increase the number of households benefiting from food and nutrition security initiatives by 200 000, and to establishing and supporting 80 000 smallholder producers. As it is women who are responsible in the majority of cases for farming decisions, they are a key group to target in initiatives aiming for increased crop-production and food-security.

Sharing WRC knowledge resources – starting out

To address the need to share the valuable knowledge being developed by the WRC with stakeholders in the agricultural learning system, especially also women farmers, a team of

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researchers at Rhodes University's Environmental Learning Research Centre worked with a wide variety of stakeholders to develop an action-oriented strategy for knowledge dissemination of rainwater harvesting and conservation knowledge for smallholder crop farmers and household food producers. The variety of stakeholders identified were those that are involved in the agricultural learning system at this level, and included agricultural colleges, research institutions, local economic development officers, extension services, farmers' associations, local media practitioners (e.g. community radio) and farmers themselves.

Two sets of materials were used as focus for the project. These are *Water harvesting and conservation* (originally published in 2011) and *Agricultural water use in homestead gardening systems* (originally published in 2010).

The two main sets of WRC materials used in the Amanzi for Food Project

These WRC materials promote low cost technology approaches to rainwater harvesting and conservation (RWH&C).

A detailed contextual analysis of the smallholder agricultural sector was undertaken which shows that there was need for curriculum innovation competence development in colleges, as well as practice-based demonstration site development. Additionally, it was found that there was an immediate local demand for knowledge of rainwater harvesting practices amongst smallholder farmers, and also from the Local Economic Development office of the Municipality as it was seeking to develop smallholder farmer capacity and farming innovations.

In initial scoping of how the agricultural colleges who are central to the agricultural learning system were using these materials, found that colleges continue to focus on larger scale farming and mainstream irrigation technologies, despite the fact that water is increasingly scarce, and that agricultural sector is the largest water user in South Africa. Currently all of South Africa's water is allocated, and there is little 'new' water for developing the smallholder farmer sector, especially in the face of climate change challenges. Developing this sector is, however, a key objective in the National Development Plan.

Establishing a learning network and strategy of practice approaches

To include all who were interested in the RWH&C practice knowledge, it was agreed to establish a learning network structure that was inclusive of all stakeholders in the agricultural learning system. In the Eastern Cape area where the learning network model was first established, the learning network was named the 'Imvothu Bobomi' learning network, meaning 'water is life'.

Within this learning network, a Training of Trainers (ToT) programme was established to mediate the new knowledge of RWH&C (offered by the WRC learning materials) and to support the stakeholders in the agricultural learning system to take up and use this knowledge. In the Agricultural Colleges, lecturers were supported to develop curriculum innovation projects which included share demonstration site development.

Other stakeholders (extension officers, Local Economic Development (LED) officers, researchers, farmers and farmers' association members) were also included in the ToT, where they too were supported to develop learning support innovation projects and to participate in the shared demonstration site development process. This brought the value of working in learning networks to the fore, as different stakeholders were able to mobilise their prior knowledge, experience and expertise in a local context, drawing on the new knowledge from the WRC, where the end result was contributions to improved knowledge exchange and farming practice amongst farmers, improved curriculum options for college students, and better support to smallholder farmers to use RWH&C knowledge in local context.

Out of this process, the Amanzi for Food project developed into a social learning innovation partnership between the WRC and Rhodes University's Environmental Learning Research Centre and local partners supported a range of diverse learning processes in this learning network. This provided for an interactive framework that allowed for co-engagement with knowledge around productive demonstration sites development which placed the farmers at the centre of the agricultural learning system.

It also challenged traditional approaches to knowledge dissemination that are largely based on the model of research-develop-disseminate-adopt (RDDA), and offered a more systemic, interactive and co-engaged model for knowledge dissemination. The foundational approach is innovation oriented and relational and practice-oriented. The project adopted a 'Strategy-as-Practice' approach which focuses in on people and the interrelations between people and practice in the emergence of strategy. Here a key feature of the project was the development of productive demonstration sites where relevant RWH&C practices could be viewed in action and used practically. These sites were in the college grounds, on individual farm or garden plots, and on an area of co-operatively farmed communal land. The development of these sites proved one of the most crucial activities in bringing the members of the Learning network together.

Participants on the Training of Trainers course, who were also members of the Imvotho Bubomi Learning Network, included college and university lecturers, agricultural extension officers, agricultural researchers, farmers and members of farmer associations, and a representative from a local economic development agency. The course was facilitated at two levels; one for those involved in the formal training sector, such as the lecturers, and the other for those involved in informal training, such as the farmers, and comprised five phases:

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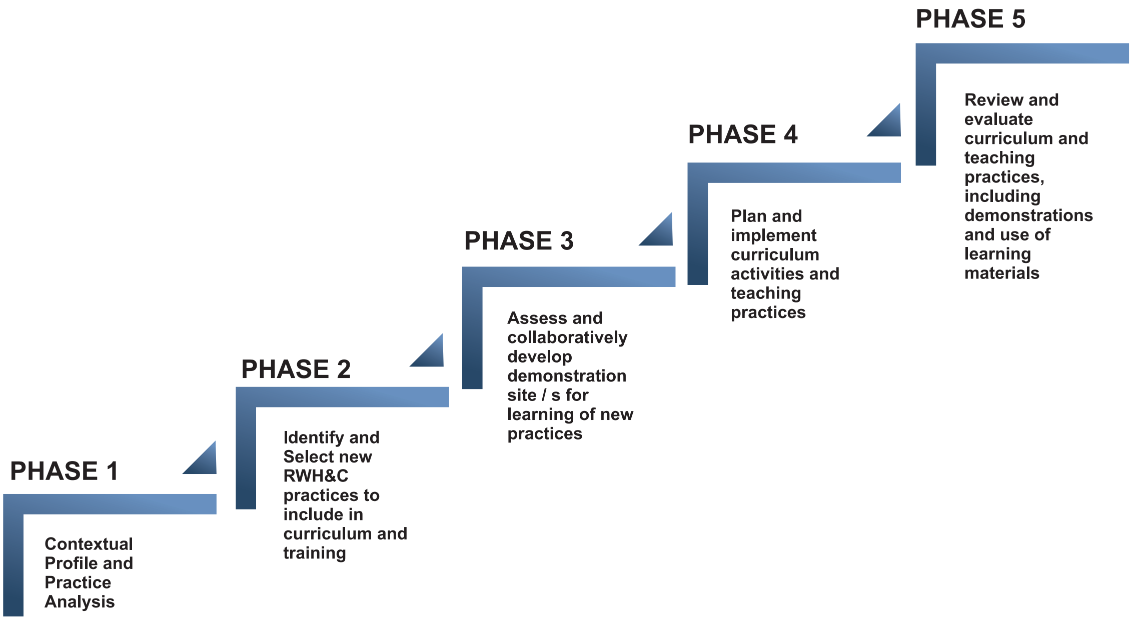

The 5 phases of the Training of Trainers course.

Participants could attain a Rhodes University NQF-accredited certificate through the successful completion of assignments and change projects directly linked to their training practices, and the majority succeeded in this.

To quote one of the lecturers at Fort Cox College which shows the bringing together of the materials and new knowledge encountered in the Training of Trainers programme with the development of productive demonstration sites for co-engaged learning: "The use of photographs and videos is one step towards a true learning experience. These shall be employed for the teaching of farm ponds as a RWH technique to college students. Of utmost importance will be the demonstration site to be erected at Fort Cox College of Agriculture and Forestry. College students, high school students, agricultural professionals, and farmers will all converge at this site for an extra-ordinary learning experience in the construction, observation, guided manipulation and use of the site."

Curriculum innovation modelling at the college has since seen the teaching of students in rainwater harvesting and conservation using the established demonstration site through agricultural engineering (irrigation), crop production and horticulture, and soil and water conservation courses.

A series of radio programmes were broadcast through the agricultural programme on the Forte FM community radio station based on the University of Fort Hare campus in Alice. Each programme involved a panel of speakers from the Imvotho Bubomi Learning Network sharing ideas about RWH&C and their experiences with this with the listeners. Listeners were encouraged to call in with questions and their own experiences, to which the panellists could respond.

For many members of the network this was the first time they had been into a radio studio, and it proved a valuable experience in using community radio to share their ideas with other lecturers, farmers and extension officers. While some were understandably nervous at being broadcast, others proved to be natural radio personalities, and took to the medium without any apparent effort or discomfort. It was also the first time the local community radio had been used as a conduit for communicating rainwater harvesting and conservation issues. In so doing it led to some farmers taking up and implementing the practice. One farmer said "I was led to water harvesting by information from my extension officer at a farmers' meeting and listening to a radio show".

However, it was only possible to implement one such learning network in some depth over a period of 18 months, but shorter ToT programmes were run, and other learning networks were emerging. A key extension to the above, was development of a media component for facilitating the expansion of access to, and use of the experience and RWH&C knowledge and materials. This involved development of a project website 'Amanzi for Food' allowing quick access and association with the key message of the programme (www.amanziforfood.co.za) which allowed multi-levelled access to the materials via various access tools, including a 'navigation tool' which served to be critical to the whole knowledge access and dissemination process, links to other social media, including a Facebook page, blogs and news items and links to other websites where the RWH&C knowledge is being shared.

Posters and Youtube videos were also developed and pilot tested to assist with visualisation of the RWH&C practices. Additionally, a community radio programme was established with a radio handbook produced out of the experience of designing and hosting the radio programmes. A significant finding out of the media component is that the various forms of media operate in relationship, requiring an integrated approach to media development for enhancing knowledge dissemination.

Importantly, the project has left some genuine tangible benefits for farmers in the Learning Network, and for agricultural training organisations.

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The model attracts national and international attention
The co-engaged knowledge dissemination / social learning model that has been developed by the project has attracted a lot of attention, especially because it has led to actual curriculum innovations in colleges while at the same time supporting farmers to improve their food production via use of rainwater harvesting and conservation practices. The project won a ***Mail and Guardian*** 'Greening the Future' award in the category 'Women in Climate Change'. Post-graduate students on the project were given the Vice Chancellors award for community engaged research, while the project as a whole won the Vice Chancellors Community Engagement Award at Rhodes University in 2016. The project was also selected for evaluation within the Department of Higher Education and Training's National Skills Development Strategy III, as it models how partnerships in a local context can improve agricultural education and training and how the colleges are situated within and can service the wider agricultural learning system. Additionally, the project was also selected as a model project dealing with critical supply and demand issues in the Partnership for Green Economy's Learning programme, and was presented at the PAGE Inter-Ministerial Conference in Germany last year.

Expanding the programme
Following this, in 2018 the project is being expanded to two other provinces where the learning network model is being developed further. This is helping with further implementation of the innovation centred action oriented strategy, involving the multi-actor Training of Trainers programme, more agricultural colleges in South Africa (and potentially elsewhere), the media-based social learning components, and further collective RWH&C demonstration site development which benefits the women food producers in practice, enhancing their food production systems, while benefiting the colleges through practice-based learning sites, and curriculum innovations. These also benefit local extension officers and the municipality's interest in green economy practice development via their smallholder farmer's development scheme. The programme also benefited the local radio station, offering local development news, and youth who were engaged in internships, by offering them practical experience.

Overall contribution of the project
Overall, the project offers a framework for a new, more engaged model of water education, training and social learning responsiveness that offers multi-benefits for all stakeholders associated with the water value chain, leaving lasting innovations in the colleges, or learning centres. The private sector could greatly facilitate this process by supporting supply of the technologies needed for small scale RWH&C practices for smallholder farmers in low cost formats.

This model is based on the concept of 'relational goods', meaning that for the smallholder and household farming sector to flourish, training models that develop relational goods (being shared new goods, concepts, or practices) that are developed co-operatively via new multi-actor-based learning and training interactions are needed. What was innovative in this case, is that the normal 'traditional' service providers of education and training, namely the colleges, were also part of – in fact central to – the social learning innovation system. This addresses an emerging problem in Africa and elsewhere that much social learning innovation tends to operate outside of the formal government systems of training. Including the colleges as central to the social learning innovation and production of water value chain 'relational goods' allows for a more sustainable approach to water education and training innovations. The impact is innovation in the learning system, as well as immediate practice benefits for multi-stakeholders.

To order the reports, *Water use and food security: Knowledge dissemination and use in agricultural colleges and local learning networks for homestead food gardening and smallholder farming Volume 1: Research and development report* (**Report No. 2277/1/16**) and *Volume 2: Action oriented strategy* (**WRC Report No. TT 694/16**), contact Publications at Tel: (012) 761 9300, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.

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PEATLANDS

National peatland database

There is a national effort underway to capture information on South Africa's peatlands in the National Peatland Database. Althea Grundling, Piet-Louis Grundling and Lulu van Rooyen explain how contributors can add their information.

Peatlands accumulate and store dead organic matter from wetland vegetation under permanent water saturated conditions and low oxygen content, making it an important resource for a variety of ecosystem services – most notably carbon sequestration and as a source of fresh water.

It is important for us to recognise the spatial distribution of peatlands in South Africa in order to understand the key processes in their formation, as well as their contribution to South African wetland ecological infrastructure.Furthermore, knowing where peatlands occur (i.e. an inventory of peatlands) will allow us to make informed decisions on managing, using and conserving these sensitive ecosystems.

Researchers are calling on all relevant communities (e.g. wetland, soil or aquatic scientists, or the agriculture sector) to submit information of known peatland sites that could be included in the National Peatland Database. All contributors will be acknowledged within the database. The peatland database will be available to the public upon request.

The National Peatland Database recording spreadsheet (MS Excel document) lists the most important attributes per sample site. There are also columns for additional scientific information, should you have it available. Please contact Dr Althea Grundling (Althea@arc.agric.za) to obtain the spreadsheet.

The list of attributes is as follows (numbers 1 to 7 being the most crucial should you have no other confirmed information available):

1. Wetland Name.
2. Contact / Project Details (e.g. Wetlands Consulting, ARC).
3. Surveyor Name and registration (e.g. SACNASP registration).
4. Acquisition Date (when site/sample/profile was recorded).
5. X-Coordinate (Decimal deg. / DD/MM/SS all WGS84).
6. Y-Coordinate (Decimal deg. / DD/MM/SS all WGS84).
7. Possible Peat site (site still needs to be confirmed).
8. Peat Thickness (m).
9. Peat Area (ha).
10. Hydrogeomorphic (HGM) Wetland Type (e.g. seep, depression, valley bottom).
11. Vegetation Cover Type (dominant sp.).
12. Red Data Species (presence).
13. Land-use in Wetlands.
14. Land-use in Catchment.
15. Other Impacts (e.g. drains, erosion).
16. Landownership.
17. Photo of Wetland (indicate copyright holder of photo).
18. Photo of Peat at the site (indicate copyright holder of photo).
19. Comments.
20. Scientific Information (if available):
    - Peat Profile Description.
    - Photo of layers/horizons (indicate copyright holder of photo).
    - % Carbon (Organic Carbon) (should be >20% organic carbon or >30% organic matter).
    - Analytical Method used to determine % C.
    - Water Level.
    - pH (this is the porewater pH that one measures in the field with a pH meter).
    - Water Quality (e.g. Electrical Conductivity / Sodium Absorption Ratio (SAR) / Exchangeable/Extractable cations/anions / Heavy metals).
    - Palynological studies (pollen).
    - Carbon Dating.
    - Present Ecological State (PES) (e.g. WET-Health; Macfarlane et al., 2009) or River EcoClassification: Index of Habitat Integrity (IHI) (Kleynhans et al., 2008).

Sampling methods

How many samples should one take for analysis? Firstly, what do you want to know? Is the wetland a peatland or not? Secondly, how much funds do you have for analysis? For the peatland database, we need % Carbon found in the top 300 mm of the profile. During soil surveys a minimum of three samples is recommended to be statistically viable.

How should one take the sample? It is important that the sample is an accurate representation. Carbon pools are typically greater in the permanent wetland zones. Avoid unusual spots (e.g. bioturbation). It is advisable that a separate sample is taken from

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each layer, with descriptions of the colour and texture of the sample. The Von Post (1922) classification system can also be used to describe the **organic matter** decomposition scale (i.e. H1 to H10). A peat profile can have different layers that represent different deposition environments (e.g. sand layer indicates higher energy; ash layer indicates desiccation and peat fire). In thicker peat layers, Carbon content also tends to increase with depth in a profile.

A peat auger is the best tool for obtaining a peat sample. If a peat auger is not available, a shovel or a spade can work satisfactorily. Take a slice of peat (about 50x50x20 mm thick) from each layer and place it in a sample bag. Mark the sample bag clearly on the outside. Use a permanent marker pen or attach a sticker or piece of paper onto the bag. Record all relevant data on the sample submission sheet. The laboratory sample should be approximately 500 grams or 250 ml. The lab does not need a large sample but 500 g will allow repeat analyses, if required.

How should one preserve the sample? It is important to keep the moisture inside. You can use plastic sample bags and seal them with a cable tie, or use large plastic zip-lock bags. You can also use a plastic sample bottle with wide mouth and lid. Keep the samples in a cool, dry place (e.g. cooler box) to prevent rotting and for transporting to the laboratory for analysis.

Carbon analysis methods

There is a difference between analysing for organic material (matter) and organic carbon. To classify as peat, the sample should have >20% organic carbon or >30% organic matter, with profile depth at least 300 mm. The depth (300 mm) is an important criterion for the wetland to be classified as a peatland. According to Joosten and Clarke's publication of 2002, "peat is sedentarily accumulated material consisting of at least 30% (dry mass) of dead organic material". There are three laboratory methods listed in Table 1: Walkley-Black (W-B), Dry Combustion (Total C) and Loss on Ignition (LOI) (Grundling et al., 2010).

Table 1: Carbon analysis methods, cost per sample and short explanation

Method	Explanation	Cost Range (inc. VAT) per sample
Walkley-Black (W-B)	This is a rapid oxidation method. The W-B method is the most suitable to measure soil organic carbon. The method can underestimate the organic carbon content, and for this a conversion or correction factor is applied (Sleutel et al., 2006). The accuracy of this method tends to decrease with higher organic C levels (>8%) (Soil Survey Staff, 1999). The method makes use of chemicals, which are difficult to dispose of in an environmentally friendly manner.	R77.52 to R89.00
Dry Combustion (Total C)	Total C refers to both organic and inorganic carbon content in soils (Schumacher, 2002). The dry combustion method is based on the oxidation of organic C and thermal decomposition of carbonate minerals. For peat, this is the preferred method to determine organic carbon content because it measures directly and no conversion or correction factor is involved. However, the amount of carbon might be overestimated by this method in areas where carbonate minerals (lime, calcrete, etc.) are present in the profile or underlying parent materials.	R89.00 to R163.02
Loss on Ignition (LOI)	This method gives you the Organic Matter (Ash + Moisture). It is based on measuring the weight or percentage loss of organic matter when exposed to a high temperature (varying between 450 and 900°C). The weight loss that occurs is then correlated to oxidizable organic carbon (Sleutel et al., 2006). The LOI method can give an overestimation of the amount of carbon.	R94.62

The dry combustion method is regarded as a very accurate method to determine total C, but only when there are no carbonate minerals present in the peat. It is also the most costly of the three methods. Should cost be a factor, one can use LOI for peat samples, taking into account the limitations of the method.

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Photos A & B: Two different peat profiles obtained using a peat auger. A) Peat profile from the Muzi System, Tembe Elephant Park, indicating different deposition environments (open-close water conditions). B) Peat profile (0-20 cm) from the Eastern Shores of Lake St. Lucia. [Photos by AT Grundling.]

Photo C: Peat profile on rock, obtained using a spade at the Kgaswane Mountain Reserve. [Photo by AT Grundling.]

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URBAN WATER USE

Busting myths around urban household water use in South Africa

As large parts of South Africa fight the grip of the current drought it is prudent to reflect on water use in the country's large cities and what could be driving people's water use behaviour. Article by Richard Meissner, Inga Jacobs-Mata and Miriam Murambadoro of the CSIR.

Human behaviour is one of the main forces in the utilisation of natural resources. Nowhere has the way people use water been more illustrative than in the current drought-ravaged Cape Town where calls for more prudent water behaviour has led to the avoidance of the dreaded 'Day Zero', a scenario where the water network would be turned off to 75% of the City and residents would have to collect water from distribution points. This article explores some myths and how these could constitute human behaviour around household water use.

Myth 1: Overflowing dams mean the drought is over

South Africa's frequent droughts have, over the years, played their part in the way the country manages and conserves water resources. Droughts have been one of the driving forces behind the South African government's water infrastructure programmes aimed at augmenting the country's water resources or to convey water from where it is in abundance to where it is needed (i.e. through water transfer schemes). Large dams have been central to many of these programmes, for example, the Gariep, Vaal, Loskop, Theewaterskloof and Inanda dams. When our large dams start running dry, and pictures of partially filled dams flash across our television screens, realisation dawns that water is in short supply.

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With the current water crisis in the Western Cape we are constantly reminded by the media that the dams supplying water are at critically low levels. The Theewaterskloof Dam has been a predominant feature in these articles. This dam is the largest contributor to Cape Town's water. Pictures of large, almost empty, dams are synonymous with drought and water restrictions.

Conversely, images of dams overflowing are often linked with a sense of water abundance. When the Vaal Dam, South Africa's fourth-largest dam, overflows the picture thereof are captured by the media and beamed across the country. While the public view these pictures, other parts of South Africa remain in the grip of a severe drought.

This was the case at the beginning of 2017, when good rains fell across the Vaal River system. Water flowing into the Vaal Dam increased its level from 26% to more than 100%. This necessitated the Department of Water and Sanitation (DWS) to open some of the dam's 60 sluice gates. Seeing the water flowing from such a large dam could create a sense that the drought is over.

Shortly after the Vaal Dam's sluices were opened, in March 2017, the DWS lifted Gauteng's water restrictions. At the same time, the department asked people not to waste water since the country was still experiencing drought conditions, reflecting a paradox between water's perceived abundance in one area and another region's water scarcity. Calls like these from DWS indicate the role of people's behaviour in water consumption rates.

In an environment driven by constant climate variability overflowing dams are temporary at best. In an environment oscillating between water scarcity and abundance, people's behaviour need to change from a sense that although we have dams to see us through droughts, we cannot continue to use water the way we do. There are no constants, like overflowing dams. The only constant would appear to be that images of overflowing dams drive us towards old water use habits, which are generally wasteful and less mindful of a future looming drought.

Myth 2: Resorting to old water use habits when it rains

A drought is a slow onset disaster with cumulative social, economic and ecological impacts over space and time. For the majority of water users, good rainfall ushers in the end of a drought. However, it is important to emphasise that drought is not necessarily the absence of rain but any deficit from the normal rainfall that occurs months or years. According to the South African Weather Service, a deficit of merely 20% of rain from the norm can result in crop failure and water shortages. A 25% decline in rainfall affects the recharging of surface and groundwater resources. The difference between a 'dry spell' and a longer term catastrophic situation could be a mere 5% less rain.

For the City of Cape Town, officials have indicated that "it will take at least three consecutive winters of above-average rainfall to make a real difference to the availability of surface water". Thus one good rainfall season in the drought-stricken Western Cape would not equate to the drought being over.

Myth 3: We have plenty of water – we just need more water-supply infrastructure

While there are very few people who still believe South Africa to be water abundant, there is still a continuous debate about whether or not supply-driven approaches such as water augmentation programmes will necessarily solve the problem of water scarcity. The DWS and the City of Cape Town recently published a ***Water Outlook for 2018*** report. This report summarises the City's stance of augmentation, which includes options such as expansion of groundwater, water reuse, desalination. These measures will not only address the water crisis in the short term, but also make a longer term contribution to Cape Town's water supply.

The City of Cape Town has implemented a diversified augmentation plan to see it through to June 2022, but due to the expense of alternative supply options the projects have only progressed to pilot stage. Table 1 outlines the City's augmentation plans, which together will add 295 Ml/day to Cape Town's water supply.

Envisaged projects	Volume of water (Ml/day)
Short-term and temporary desalination	16
Groundwater abstraction	150
Spring water abstraction	4
Water reuse	125
Total	295

Source: Water Outlook Report

According to the Water Outlook report, non-surface water augmentation schemes are a much more expensive source of water compared to rain-fed dams. Even under very poor rainfall conditions such as that experienced in 2017, the volume of water added to the dams was the equivalent of around 720 ML/day. Cape Town will thus, for the near future, remain reliant on its rainfall-fed dams, and thus remains vulnerable to drought. Cities around the country have similar challenges.

Myth 4: As long as I pay I can use as much as I like

According to DWS, the average water tariff for bulk water is R3.84 per cubic metre. This tariff varies widely from R2.78 to R7.26 per cubic metre. This variation is subject to the availability of water, the distance of distribution and the quality of the raw water needing purification. At local government level, the household water tariff differs from municipality to municipality. Table 2 presents three municipalities' water tariffs. This paints a picture of how much residents living in these large metropolitan areas paid for water in 2017/18.

Looking at this table could provide one with the sense that as long as a resident pays for water, and the more he/she pays for the resource, the more water that person can use. This is, however, not the case. The tariff escalates as water consumption increases in a bid to curb excessive water consumption at household level.

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Municipality	Volume of water (kl) consumed at household level per month	Tariff Rand/ kilolitre
City of Ekurhuleni	0-6	R0
	7-15	R14.89
	16-30	R18.24
	31-45	R22.69
	46 or more	27.98
eThekwini Metropolitan Municipality	0-6	R16.20 (property rateable values greater than R250 000)
	6-25	R19.14
	16-30	R25.48
	25-30	R39.31
	30-45	R43.24
	45 or more	
City of Johannesburg	0-6	R7.14
	6-10	R7.58
	10-15	R13.17
	15-20	R19.63
	20-30	R26.96
	30-40	R29.22
	40-50	R37.11
	More than 50	R38.72

The availability of water is an important consideration for local authorities. Municipalities can, if forced, introduce a 'punitive tariff' in a bid to compel residents to consume less water. For instance, the City of Cape Town planned to introduce a so-called "drought tariff". Under this tariff the use of 6 kl/month would have increased from R28.44 to R145.98 of the total household water bill. The City Council did not introduce the new tariff after it received thousands of comments against the new tariff's introduction.

The ethical question here is, if a person is wealthy enough to use as much water as he or she can pay for, is it fair for that person to actually do so? We say no, because all human beings and other biological organisms require water for survival. Having more money or no money at all does not doom one's survival, but having no water does.

Myth 5: We save water by using borehole water
Finally, there is the misconception that by using borehole water saves water because it is not generally treated. This perception has been compounded in the past by some municipalities that have promoted the use of borehole water as an alternative to the conventional municipal supply during times of moderate water restrictions.

This has been done in an effort to alleviate the pressure on municipalities to provide sustainable and quality municipal services to all residents within their jurisdictions. The use of boreholes to supplement, or replace, the conventional municipal supply is becoming more common, especially in new developments outside of traditional city limits. This has, however, led to unrestricted drilling of boreholes in some areas, the use of which is often difficult to manage by local authorities.

While it is not easy to control how much water people extract from their boreholes, groundwater still needs to be used responsibly. Moreover, the unfettered use of this underground resource is often not sustainable given the inextricable linkages between groundwater and surface water. It was found that in 2017 many borehole users in Cape Town were irrigating their gardens after 09:00 despite the Level 3B restrictions enforced at the time. Under the current Level 6B restrictions outdoor use of borehole water is strongly discouraged.

The misperception about the use of groundwater may have originated from the old Water Act of 1956, which drew a clear distinction between public and private water. Under the old Water Act, water from a borehole would ordinarily have been considered as privately-owned water and its use therefore largely restricted. According to the National Water Act of 1998, however, the state is the custodian of all water resources, regardless of its origin, and holds it in trust for the nation and allocates user rights.

Under the 1998 Act, water use for specified purposes is subject to certain thresholds, beyond which a licence must be obtained. Groundwater for domestic use is considered a Schedule 1 use, and therefore requires no water use licence. However, some municipalities have bylaws requiring the registration of boreholes.

These are some of the myths driving people's behaviour when they consciously and unconsciously consume water. Water engineered infrastructure, paying for water, and using borehole water does not equate a right to waste water. These resources only provide us with an assurance of supply.

Droughts are the only constant that influence this assurance of supply. By taking variability and change into consideration, another variable that could positively influence an assurance of supply would be changing human behaviour towards using water sparingly.

Lani van Vuuren

An image of a spilling dam can be construed as a sign that water is available in abundance

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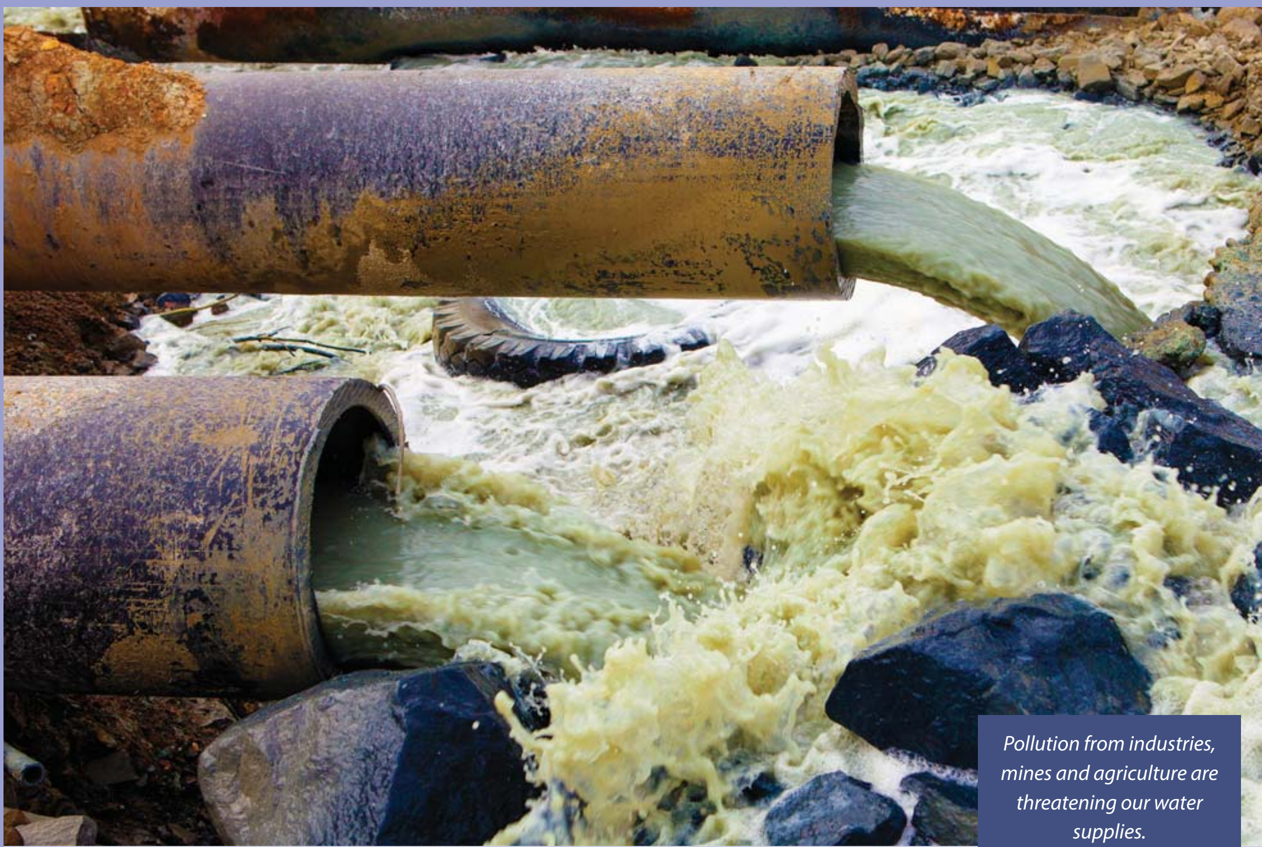
Water quality – taking care of our rivers and streams



Pollution from industries, mines and agriculture are threatening our water supplies.

South Africa is a water scarce country. Since we don't have a lot of water to go around we have to take care of the little water we have. Unfortunately, human activities have polluted many of our rivers and streams.

Rivers are often seen as the mirrors of the environment. They reflect whatever is going on in the catchment that they drain. Everything that happens in a catchment area is reflected in the quality of the water that flows through it, because the results of human activity and lifestyle ultimately end up in rivers, through runoff.

Healthy streams, wetlands and rivers support a great variety of water life. All life in the water is dependent on the interaction within the river itself and in the surrounding catchment. These processes can either maintain a healthy ecosystem or disrupt ecological processes and degrade the water supply.

Changes in water quality occur naturally along the length of a river; however, these changes may be significantly influenced by human activities. Industries, agriculture and urban settlements produce nutrient concentrates (sewage effluent and fertilisers) and toxic substances (poisonous pollutants) which can affect water quality.

What is polluted water?

Water quality is defined as water which is safe, drinkable and appealing to all life on earth. It should contain no chemical or radioactive substance that is harmful to the health of any life. It should be free of disease-causing organisms and stable in terms of corrosion or scaling. Polluted water is water that is not safe and not healthy for people and animals to drink or to wash in.

Polluted water is particularly dangerous to water plants and animals. Polluted water is also particularly dangerous to people

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Plastic and other trash is a visible pollutant in our rivers.

who get their water directly from a river or dam. In South Africa the scarce freshwater is decreasing in quality because of an increase in pollution and the destruction of river catchments, caused by urbanisation, deforestation, damming of rivers, destruction of wetlands, industry, mining, agriculture, energy use, and accidental water pollution. As the human population increases, there is an increase in pollution and catchment destruction.

There are two different ways in which pollution can occur. If pollution comes from a single location, such as a discharge pipe attached to a factory, it is known as **point-source pollution**. Other examples of point source pollution include an oil spill from a tanker, a discharge from a smoke stack (factory chimney), or someone pouring oil from their car down a drain. A great deal of water pollution happens not from one single source but from many different scattered sources. This is called **nonpoint-source pollution.**

When point-source pollution enters the environment, the place most affected is usually the area immediately around the source. For example, when an accident occurs at a chemical plant, the chemicals are concentrated around the plant itself. This is less likely to happen with nonpoint source pollution which, by definition, enters the environment from many different places at once.

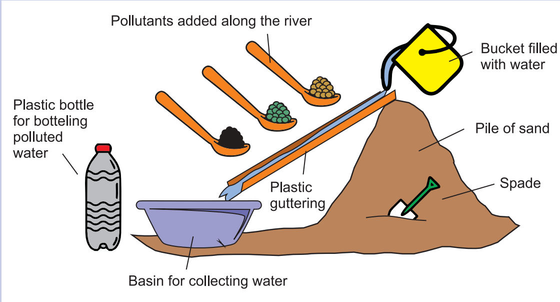
How do we know a river is polluted? Some water pollution is hard to detect. There are two main ways of measuring the quality of water. One is to take samples of the water and measure the concentrations of different chemicals that it contains. If the chemicals are dangerous or the concentrations are too great, we can regard the water as polluted.

Measurements like this are known as chemical indicators of water quality. Another way to measure water quality involves examining the fish, insects, and other invertebrates that the water will support. If many different types of creatures can live in a river, the quality is likely to be very good; if the river supports no fish life at all, the quality is obviously much poorer. Measurements like this are called biological indicators of water quality.

What can we do to control water pollution?

- Correctly dispose of hazardous household products. Avoid letting contaminated water such as chemicals, soaps, grass clippings etc. run into storm drains.
- Recycle and dispose of all rubbish properly. Ensure that litter is thrown in the rubbish bin and does not get blown away.
- Use natural fertilizers in the garden.
- Never throw chemicals, oils, paints and medicines down the sink drain, or the toilet. Check with your municipality about the correct disposal of these pollutants.
- Volunteer for a beach/river clean-up, tree planting or water quality monitoring.
- Report polluters! If you see someone dumping pollutants into a river or stream alert your local authority.

Make a model of a polluted river



What do you need?

1. A hose or bucket to provide a source of water
2. A small spade
3. Guttering o halved swimming pool hose
4. Basin or 2L plastic bottle for the dam
5. Sand, food colourants, lentils, coffee, and other harmless substances that can be used as pollutants
6. Bottles, jars
7. Plastic bottle for bottling polluted water
8. Spoons
9. Paper, pens and coloured pencils

What do you do?

Choose harmless substances to represent real pollutants in rivers, and decide on the amount of each pollutant to add to your river. Give reasons for your choice.

Design and build a short river in the school ground (or in your garden). You will need a source of water and a dam at the end.

Pour the water into the model. As the water flows down the river the pollutants can be added.

Collect the water in a bottle. Write a label for the bottle of polluted water. The label must show what is in the water. Keep this bottle in your classroom to remind you that we need to take care of our rivers.

Source: www.waterwise.co.za

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CALITZDORP DAM – CELEBRATING SOUTH AFRICA'S OLDEST WORKING CONCRETE GRAVITY DAM WALL

Tucked behind Besemkop in the Nel's River valley, about 5 km north of Calitzdorp in the Little Karoo lies the Calitzdorp Dam or, more correctly, Nel's River Dam. Completed in 1918 it is South Africa's first and oldest concrete gravity dam that was built for irrigation purposes and that is still in working condition – a living pioneering engineering achievement.

Nel's River Dam, which took about five years to build, comprises approximately 110 000 cubic tons of concrete. The dam wall has a height of 18 m and length of 213 m. The spillway consists of a low concrete overflow with a drainage canal that was blasted into the side rock and left unlined. The permissible height of the overflow is 1.8 m. The dam provides water to 70 irrigation users of the Calitzdorp Irrigation Board with their 520 ha of scheduled irrigation lands, as well as the approximately 4 700 residents of the town.

Associate Professor of History at the University of Stellenbosch, Wessel Visser, has captured the fascinating history of the dam and the irrigation scheme it serves. For more information about this book, ***The Nel's River dam of Calitzdorp, 1918-2018: South Africa's oldest working concrete gravity dam wall*** (written in both English and Afrikaans) contact Prof Visser at
Email: wpv@sun.ac.za

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The Water Research Commission not only endeavours to ensure that its commissioned research remains real and relevant to the country's water scene, but that the knowledge generated from this research contributes positively to uplifting South African communities, reducing inequality and growing our economy while safeguarding our natural resources. The WRC supports sustainable development through research funding, knowledge creation and dissemination.

The knowledge generated by the WRC generates new products and services for economic development, it informs policy and decision making, it provides sustainable development solutions, it contributes to transformation and redress, it empowers communities and it leads various dialogues in the water and science sectors.

The WRC Vision is to have highly informed water decision-making through science and technology at all levels, in all stakeholder groups, in innovative water solutions through research and development for South Africa, Africa and the world.

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